AN EXPLORATION OF TECHNOLOGY TRANSFER CONTROL: A CASE STUDY OF WRIGHT LABORATORY

THESIS

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AFIT/GSM/LAS/94D-1

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THESIS

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Acquisition Management

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William K. West

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Abstract

Federal laboratories, system product centers, and military logistics centers are being challenged to leverage national investments in technology beyond their traditional customer base -- technology transfer. Participation in domestic technology transfer is growing at an astounding rate. Additionally, the federal government has invested and continues to invest billions of dollars into active defense conversion, dual-use technology, and technology transfer.

The objective of this research is to explore how one government laboratory controls its technology transfer process, in both the near and long terms. This research examines the motives for participating in technology transfer. The researcher presents several of the processes that are used throughout the federal laboratory system and recommends the process model best suited for active technology transfer organizations. The research also discusses near and long term metrics and their suitability for use. Additional topics investigated include technology transfer definitions, technology transfer laws, and barriers to measuring technology transfer.

The researcher interviewed participants at Wright Laboratory in a case study methodology to determine their method for control of their technology transfer process. Data are presented from these interviews and results examined. The researcher offers future opportunities for research in the area of technology transfer.

AN EXPLORATION OF TECHNOLOGY TRANSFER CONTROL:

A CASE STUDY OF WRIGHT LABORATORY

I. Introduction

Research Objectives

The objective of this research is to provide a case study of how one government laboratory -- Wright Laboratory (WL), Wright-Patterson Air Force Base, Ohio -- controls its technology transfer program. Literature and research exists on a variety of technology transfer areas, but no known research has been performed to investigate if government organizations are measuring the success of their technology transfer programs in order to determine accomplishment of their objectives. Many authors concede the difficulty in measuring and controlling technology transfer, but all recognize the importance of it (1: 345; 2; 3: 164, 170; 4: 141-142). Research objectives are as follows:

1. Determine the motives for WL involvement in technology transfer.
2. Determine the technology transfer process in WL.
3. Determine measures used to assess the success of the technology transfer program.

Scope

This research predominantly pursued the opinions of personnel in the technology transfer role of sponsor with regards to their perceptions about their agency's involvement in technology transfer (5: 64). The unit of analysis was domestic government agencies which were involved in technology transfer. This research is not intended to find fault in organizations nor to be generalized to all government agencies (6: 142-143). The case seeks to provide in-depth analyses of a typical government laboratory as an aid for the Air

Force Material Command (AFMC) Technology Transfer Metrics Working Group, a subset of the AFMC Technology Transfer Integrated Product Team (IPT).

Definition of Terms

The following terms will be used repeatedly throughout this research as common descriptors of technology transfer actions.

1. Control is operationally defined as utilizing measures to assess the efficiency and effectiveness of a process in meeting the objectives of an organization.

2. A Cooperative Research and Development Agreement (CRDA) is an agreement between Air Force (AF) research and development facilities and a commercial partner to mutually pursue a specific technology or research and development effort.

3. Defense conversion is defined to be the process of demilitarization of the contractors comprising the industrial base of the Department of Defense (DoD) (7: Section III, 6).

4. Dual-use technology is defined as technology developed for both public and private uses at the beginning of its development (8).

5. Industrial Policy is defined as the series of decisions and actions made by the political forces of the United States regarding the economy (7: Sec III, 1-2).

6. Measurement is defined as the process of examining certain characteristics of interest (9: 1-7).

7. Metric is defined as a measurement made over time in order to communicate vital information leading to the improvement of a process (9: 1.7-1.8).

8. Technology is defined as products, processes, facilities and people owned by the Air Force (10).

9. Technology adopters are defined by Spann as those potential users of government technology (5: 64).

10. Technology developers are defined by Spann to be those that develop and apply technology (5: 64).

11. Technology sponsors are those that fund technology development, disseminate information, and facilitate their transfer (5: 64).

12. Technology pull is a needs generated technology transfer process model.

13. Technology push is a means generated technology transfer process model.

14. Technology transfer is defined as dissemination of government developed technology to commercial applications (2). A variety of other definitions will be offered throughout this thesis similar to Guilfoos' definition.

15. Technology transition is defined as dissemination of government developed technology to other government applications (2).

Relevancy

The relevancy of this research is two-fold. First, the nation is currently intent on maximizing the societal benefits from government laboratories. Members of congress, the presidential administration, private industry, and state organizations are involved in technology transfer more than ever before (11: 13). Over $1B is budgeted for defense conversion and technology transfer in FY95 (12: 1-2). Technology transfer programs must be measured to assess the value of the investment, and the efforts of technology transfer must be reconciled against the objectives of the organization. Second, AFMC has launched an intense effort in technology transfer. Quarterly meetings are held across the country to discuss the benefits, strategies and opportunities for technology transfer within AFMC. Working groups are investigating efforts in metrics and technology marketing. This research will provide an aid to the Metrics Working Group in their efforts to identify technology transfer metrics for the command.

Thesis Overview

Chapter Two of this research focused on technology transfer background, technology transfer processes, motives for organizational involvement in technology transfer, barriers to measuring technology transfer, and current methods for measuring technology transfer

success. A table of technology transfer motives and success metrics is provided at the conclusion of the chapter to summarize the focus of the chapter.

The methodology approach presented in Chapter Three is an exploratory case study. Literature review and expert interviews were utilized to develop knowledge in the technology transfer field and to help define research focus. This knowledge was transformed to interview questions used to develop a case study of WL's method of control for their technology transfer program. Chapter Four presents the data collected during elite interviews and document review at WL. Chapter Five provides conclusions and opportunities for future research.

II. Literature Review

Background

Economists have debated the value of intervention in the economy of a nation for generations. Should the government intervene in the economy or should the government allow the market to operate on its own. The philosophy of the Bush administration was that government regulation could rarely improve well functioning markets, and would usually make things worse (13: 7). On the other hand, the philosophy of the Clinton presidency is management of the economy through explicit industrial policy or strategy. This is emphasized by the appointment of Robert Reich, a noted proponent of industrial policy, as the Clinton Secretary of Labor (13: 2, 7-9).

According to prominent economists, industrial policy strikes at the heart of many national issues. Reich contends that America has always had industrial policy, whether implicit, as in the Reagan military build-up of the 1980s, or explicit, via the more liberal method of direct subsidy (14: 159-162). The consideration is not of the existence of an industrial policy but merely of its form. Other economists, including Michael Porter, proclaim that the basic philosophy of industrial policy, whether explicit or implicit, is flawed. Only innovation and resultant productivity increases on a local level will create national wealth on a global level (15: 74; 16: 8). Porter believes government policies that succeed should create a favorable environment to companies seeking competitive advantage through innovation and technology versus those seeking government assistance and involvement (15: 86).

One author defines industrial policy as the set of government policies that perturb the allocation of resources or effect their relative level of economic activity (13: 2-3). Industrial policy activities purposefully develop or retrench various industries in a national economy in order attempt to maintain global competition (13: 2). The central premise of industrial policy is that the nation's welfare and interest cannot be optimized by the private

market alone (13: 3). Freidrich von Baron termed industrial policy as fatal conceit in that government believes it can predict the needs of the economy and pursue the right courses of action (7: Section III, 9). A classic example of industrial policy was the government bail-out of Chrysler Corporation, which saved a failing enterprise (Chrysler) in order to maintain effective national competition and global competitiveness (7: Section III, 8).

Many authors have discussed the elements of an industrial policy. Certainly, such tools as tax incentives, subsidies, special government procurements, grants, low interest or guaranteed loans, and administrative guidance are available for economic manipulation (13: 3; 15: 74). However, other authors envision the industrial policy issue in a different manner. Kasten argues that the elements of industrial policy are such things as investments in dual-use technology programs at the system level, technology infrastructure investments and active technology transfer efforts (17). Other authors include defense conversion as an element of industrial policy (18: 238).

The discussion of technology transfer as an active part an industrial policy should not imply that the literature is either favorable or unfavorable towards implementation of a managed economy. In fact, the literature is generally split. Most economists believe in the same end product, creation of national wealth, but disagree on the method of achieving it (19). However, it has been demonstrated through economic studies that elements of industrial policy, including technology transfer, can be achieved at a low cost (17). Essentially, the technology has been developed in pursuit of a national interest, such as major military projects. Resultant commercial spin-offs, or technology transfers, are considered an added benefit or bi-product of the original discovery. For example, high temperature, corrosion-resistant titanium alloys developed for the skin and structure of the National Aero-Space Plane (NASP) are also being used in oil well bolts (20: 5).

The important ingredient not accounted for in traditional weapon system cost effectiveness studies is the dual value of the technology created. First, is the value to the intended application. Second, is the value to other areas as spin-offs or transfers.

Therefore, technology transfer may be the only element of industrial policy that requires no active, centralized government planning as is the case in defense conversion, dual-use technology, or infrastructure investments. This research focused on the technology transfer elements of industrial policy.

Technology Transfer

Experts have chosen to define technology transfer in a variety of ways. These definitions range from a managed process of conveying technology from a developer through an adopter, to the more detailed definition of movement of government funded or developed technology to outside agencies or persons (5: 63-64; 21: 94; 22: 180; 23). Dawson offers several complete definitions in a 1986 domestic technology transfer research effort. Dawson also points out that appropriate technology transfer is to domestic as opposed to foreign companies (24: 17-22). Dakin provides a more working definition with technology transfer as the conversion or commercialization of new knowledge into products or services (25: 5). Most government technology transfer operatives, insert the term government in front of knowledge in Dakin's definition, as well as calling it domestic technology transfer. A more thorough definition of domestic technology transfer is offered by Air Force Policy Directive (AFPD) 61-3 as:

> Oral or written information or data; hardware; personnel services, facilities, equipment; or other resources relating to scientific or technological developments of an Air Force Research, Development, Test and Evaluation activity, provided or disclosed by any means to another Federal agency; a state or local government; an industrial organization; including corporation, partnership, limited partnership, or industrial development organization, university, or other person to enhance or promote technological or industrial innovation for a commercial or public purpose. (26)

Common elements of all definitions are a managed process to move technology knowledge from one organization to another, preferably domestic. Technology transfer involves a degree of specificity in terms of the origin of the technology knowledge and to whom the technology knowledge is to be transferred (24: 82-83). This statement by

Dawson depicts a plan and process to move technology form origin to destination. Transfer should be contrasted with technology transition which is the dissemination of government developed or funded technology to within the government; both to its intended purpose, as well as other applications (2). There is margin for interpretation and misinterpretation as to what technology transfer is, as evidenced by the definitions.

Technology transfer is not a new idea. It officially began with the space program. The most likely explanation being the rapidly expanding technological advances originating with the sophisticated National Aeronautics and Space Agency (NASA) programs (22: 180; 7: Section I, 8).

President Kennedy bolstered technology transfer in the 1960s by setting the goal of reaching the moon by the end of the decade, and challenging NASA to direct the focus of the country to this end. Transfers from the Apollo program include such things as the computer, integrated circuits, gas turbines, and corrosion-resistant paint (22: 48-49). Arguably the most effective technology transfer program resides within the Agriculture Research and Extension Services. They have been in the technology transfer business for many years, and spend nearly half of their research and development budget on dissemination and transfer of technologies (16: 10). Even with these demonstrated successes, not many government activities were interested in the topic until congress mandated involvement (4: 138).

Congress attempted to change the attitudes of the government laboratories with enactment of the Stevenson-Wydler Act of 1980 (Public Law 96-480), which mandated the active transfer of technology out of the laboratories into the commercial sector. The Federal Technology Transfer Act of 1986 (Law 99-502) elevated the attention on transfer by authorizing the use of Cooperative Research and Development Agreements (CRDA)s, and requiring government laboratories and research organizations to invest .5 % of their budget in technology transfer (4: 139-140). With the federal research and development budget of $70.1 billion (FY93), this mandate could designate as much as $350 million for

technology transfer (27: 2). As the decade progressed into the 1990s the federal government grew more activist in funding defense conversion, dual-use technology and technology transfer by specifically appropriating money.

The Department of Defense Appropriations Act of 1993 (Public Law 102-39) appropriated funding to the The Advanced Research Program Agency (ARPA), a Department of Defense (DoD) agency, for defense conversion. Congress provided $975 million to ARPA for dual-use critical partnerships, manufacturing partnerships, regional technology alliances, and defense manufacturing extension programs (28: 8).

Congress is very interested in mandating and funding defense conversion and technology transfer, often referred to as dual-use technology (29: 440; 4: 140). In response, ARPA, The Departments of Energy (DoE), Commerce (DoC), Transportation (DoT), Defense (DoD), and NASA are all actively pursuing government and industry commercialization consortia. Collectively, these agencies are investing billions of dollars in pursuit of defense conversion, dual-use technology and technology transfer (30: 3; 31: 2; 32: 8; 33: 6; 34: 5; 35: 4).

Technology transfer enthusiasts are currently enjoying this heightened awareness for technology transfer, as well as the general lack of oversight for the funding being provided to them. On the one hand, technology transfer has political appeal. Several major programs are being funded, in part, due to their technology transfer possibilities (36: 134). On the other hand, measurement of results has not been a primary focus of technology transfer agents. This is true even during this period of expanding attention (16: 19). Eventually technology transfer agents will be asked to balance the costs with the objectives and level of success of the technology transfer efforts. In fact, David Leach, of ARPA, presented a briefing at the 1994 Dayton Society of Automotive Engineers concerning these very topics. This manager has been challenged by his superiors to develop and implement an objectives, success, and measurement definition effort for the ARPA Technology Reinvestment Program (TRP) during 1995 (37).

This literature review will examine the latest definitions of the managed process of technology transfer, the objectives for technology transfer, the role players in the technology transfer process, methods to measure successful technology transfer, and barriers to measurement of technology transfer.

Nine specific findings by Digman in 1979 set the initial stage for this research:

1. Technology transfer is an important, complex, and poorly understood process.

2. Innovations are spread or diffused according to the rules of diffusion theory.

3. There is a lack of communication and unity of purpose between the developers of technology and the users of technology.

4. Successful technology transfer depends more on the personal actors than upon formal dissemination means.

5. There is a myriad of government and industrial programs concerned with information dissemination, especially technical information.

6. The information activities of government agencies seem preoccupied with goals such as maximizing transfer, whether or not this is possible or even desirable.

7. In spite of various Federal agencies' attempts to increase the transfer rate, the rate of utilization is not high.

8. Organizational structures and practices affect the innovation process, but a single organizational model offers a master solution to the problem of innovation.

9. Innovators are the key elements in the innovation process (38: 38-39).

Dawson's 1986 thesis added to the findings of Digman:

1. The concept of technology is subject to misunderstanding due to its frequent association with objects or hardware.

2. Technology transfer represents a linking mechanism between technology source and user.

3. There are a variety of roles which are significant in the technology transfer process.

4. The federal infrastructure for promoting technology transfer is mostly passive due to the emphasis on systems to collect and disseminate technical information.

5. DoD's role in technology transfer appears to be largely passive, as well.

6. Technology transfer models exist that aid in explanation of the technology transfer process, but none are predictive (24: 82-87).

Current thought on technology transfer serves as a focus for this literature review:

1. Technology transfer is a complex task (39: 1; 25: 4-6).

2. High transfer failure rates persist throughout industry, government and academia (40: 5).

3. Measurement of technology transfer success is a primitive science, but there is a growing demand for it (16: 8, 19).

4. There is little evidence of successful technology transfer (4: 138).

5. The definitions of a successful technology transfer vary (11: 15).

Technology

To understand technology transfer, one must first understand technology. Technology is classically defined as the sum of the ways in which a social group provide themselves with the material objects of their civilization (41). Roman defined technology in several manners.

> Technology is the state of the art in a socioeconomic environment.
> Technology is systematic utilization of knowledge in any cultural environment; it is the application of scientific information. (22: 2)

Dakin defined technology as the ground between science and business, and also as the conversion or commercialization of new knowledge into products or services (25: 2-3). Dawson offers many similar definitions of technology in the 1986 research (24: 10-11). The Air Force Material Command (AFMC) Process Action Team (PAT) defined technology as products, processes, facilities and people owned by the Air Force (10). It is interesting to point out that the AFPD for the definition of technology transfer failed to provide a corresponding definition for technology. Technologies that can be transferred are often referred to as dual-use technologies, which Gansler defines specifically as

technologies that will benefit both the civilian economy as well as the government (42: 236).

Technology is in a continuing state of development until it reaches its final form. Change and improvement to the technology often occurs after the technology is converted into a commercial product. Technology increases in value as it moves through the process of commercializing or converting new knowledge into products or services. At the conclusion of the cycle, the state of knowledge is greater than at the beginning of the cycle (25: 3).

The development of technology is not a linear progression. Many steps are repeated or deleted out of necessity or time constraints. Many technologies may proceed through the development cycle together, each with a potential set of applications. It is also clear that the technology development cycle overlaps the technology transfer process cycle. The start of the technology transfer process can begin at any point during the technology development cycle. In essence, technology can transform into commercialization opportunities at any time. Dakin emphasizes that throughout the technology development cycle the technology transfer agents must continuously consider two things, scientific and economic proofs. First, will the technology work for its intended purpose, and second will the technology provide an economic gain? Failure in either of these areas may necessitate termination of the technology development effort (25: 38-39).

Many other authors have recognized the value of technology to both the area for which it was developed, such as in a military system, and for other dual-use commercial applications (43: 4-11; 44: 119). Additionally, congress, in defense authorization and appropriation bills, has specifically referred to the fact that the National Aero-Space Plane (NASP) program has dual objectives (36: 134). The first objective being development of technologies to permit low-cost, flexible access to space. The second objective being transfer of the NASP developed technologies to other sectors, such as commercial applications . Success in technology transfer is thought to be ancillary to the primary

mission of technology development, but nonetheless important (25: 7). Dawson describes the duality of technology transfer as either horizontal or vertical. Vertical transfer is the flow of technology from the laboratory to a given application for which it was developed. Horizontal transfer, on the other hand, is described as secondary applications that were not the original intent of the technology development (24: 16).

Technology Transfer Laws

Congress viewed the transfer of technology, whether vertical or horizontal; primary or secondary, as important enough to have mandated and incentivized it materially through several actions since 1980.

TABLE 2.1

TECHNOLOGY TRANSFER LAWS (4: 138; 45: 11-12)

Bill Title	Date	Objective	Main Points
Freedom of Information Act, Public Law 89-544	1966		- Provided a vehicle to inform the public about federal government activities - Provided the right to request agency records and have them made available promptly.
Stevenson-Wydler Innovation Act, Public Law 96-480	1980	Promoted technological innovation for U.S. economic, environmental, and social goals.	- Instructed agencies, including federal laboratories, to participate in technology development and transfer activities. - Required most federal laboratories to establish an Office of Research and Technology Application (ORTA).
Bayh-Dole Act, Public Law 96-517	1980	Promoted innovation by allowing small business firms and nonprofit organizations to patent inventions arising from research and development funding with federal dollars.	- Allowed nonprofit organizations and small businesses to retain title to federally funded inventions.

Bill Title	Date	Objective	Main Points
Small Business Innovation Development Act	1982	Facilitated small business access to federal contracts.	- Required agencies with research and development budgets exceeding $100M (FY82) to establish a Small Business Innovative Research (SBIR) Program.
Presidential Memorandum on Government Patent Policy	1983	Allowed all contractors to claim rights to technologies developed under federally funded grant, contract or cooperative research and development agreement.	
Title V of the Trademarks - State Justice Institute - Semi Conductor Chips - Court Patent Act	1984	Extended retention of title rights to Government Owned - Contractor Operated (GOCO) organizations.	- Allowed nonprofit GOCOs to retain title rights to technologies they developed with federal funds.
Federal Technology Transfer Act, Public Law 99-502	1986	Included cooperative research and development to the Federal Laboratories role in technology transfer (Amendment to the Stevenson-Wydler Act of 1980).	- Encouraged federal laboratories to engage in cooperative research and development arrangements with state and local governments and nonprofit organizations. - Established the Federal Laboratory Consortium (FLC).
Executive Order 12591, Facilitating Access to Science and Technology	1987	Required Department of Energy laboratories to identify research areas key to national competitiveness and encouraged support for consortia and personnel exchange.	- Directed federal agencies with government-operated laboratories to delegate authority to the laboratories to license, assign or waive intellectual property developed under cooperative agreements. - Encouraged large businesses to obtain title to inventions which stemmed from joint research.
Omnibus Trade and Competitiveness Act, Public Law 100-418	1988	Redesignated the National Bureau of Standards (NBS) as the National Institute of Standards and Technology (NIST) in order to assist the private sector in capitalizing on advanced technologies.	- NIST responsible for assisting industry in technology development necessary to improve manufacturing processes and to facilitate more rapid commercialization. - Established the NIST Advanced Technology Program (ATP) for assisting businesses in the commercial application of generic research results and the refinement of manufacturing technology.

Bill Title	Date	Objective	Main Points
Small Business Administration Re authorization and Amendment Act	1990	Established the Technology Access Program (TAP) to increase small business access to data base services that provide expertise and business information.	
American Technology Preeminence Act, Public Law 102-245	1991		- Extended Federal Laboratory Consortium mandate through 1996. - Allowed exchange of intellectual property between participants in a Cooperative Research and Development Agreement (CRDA). - Required a report on the advisability of CRDAs that would permit federal contribution of funds. - Allowed laboratory directors to give excess equipment to nonprofit organizations.
Small Business Technology Transfer (STTR) Act, Public Law 102-564	1992		- Established the STTR program.

Even with mandated legislation, systematic evidence of its successful technology transfer is in short supply (4: 138). The most misunderstood premise in this shortfall is that commercial success does not necessarily follow a technologist who builds a better product, creates an invention or makes a breakthrough (25: 4-6).

Many consider the management of technology to be too complex to attempt. The major reason being that each transfer is unique, and may occur by any one of several techniques. However, Dakin stresses that technology transfer is manageable and should be approached with traditional management means (25: 81). First, organizations involved with technology development and transfer must set objectives. Second, they must set strategies to achieve the objectives. Third, they must determine and obtain resources required to meet the objectives. Fourth, they must develop a process or processes to achieve the strategies, and finally, an implementation plan must be created.

Organizations must determine whether technology transfer is to be an explicit, primary objective, or is it to be a means to a greater objective. If it is to be a means to a greater objective it is considered a secondary organizational objective or strategy. General Ronald Yates established technology transfer as a primary objective of AFMC. His statements at a recent conference reflect this:

> Aggressively share our dual use technology and technical capabilities with the U.S. public and private sectors. (46)

The DoE has a similar set of objectives, with technology transfer playing a primary role. The DoE revamped its series of business lines from four to five, with the addition of industrial competitiveness. The vision of the industrial competitiveness business line is proof of the broad technology transfer efforts on-going, and of the objective of economic impact:

> In the year 2010, the DoE will use its leadership in energy, science, and technology to help sustain long-term economic growth to create high-wage jobs and a cleaner environment. Because of our record of success, industry seeks out DoE as an innovative and productive partner. Working together, DoE, industry, and other Federal agencies have made the U.S. economy the most productive in the world in its use of energy, material and human resources. (47: 109)

The McGraw-Hill Federal Technology Report printed an article proclaiming that NASA had adopted an agenda to promote technology transfer as a major duty. An important facet of this new policy is meeting mission-related goals, as well as enhancing the economic security of the United States through technology transfer (48: 1).

Others have developed technology transfer as both a primary objective of the organization, as well as a strategy to achieve other primary objectives within the organization. The NASP Joint Program Office (JPO) has created an Integrated Product Team (IPT) solely to transfer technology to private and public applications. The objective of this IPT is to meet the federal mandates, as well as leverage the taxpayer investment in NASP technology through commercialization. However, the team also transfers technology to support other objectives of the NASP program, such as pursuit of future

hypersonic systems. These objectives include transfer of technology to commercial and public sectors so that the technology can be improved, reduced in cost, or made more readily available via the commercial or public marketplaces. This effort, although a primary objective of the IPT, is a strategy to improve the likelihood of the existence of hypersonic vehicles in the future, a primary objective of the NASP JPO (49). Chapman provided that NASA has both primary and secondary uses for its technology (3: 165).

Why Technology Transfer?

Organizations have become involved with technology transfer at an increasing rate over the past few years (50: 30; 4: 151). Technology transfer symposiums and lessons learned sessions are creating a new business for conference organizers. The reasons are plentiful and will vary from purely political to purely financial. Spann recommends, based on research conducted in 1993, that technology transfer agents set clear organizational goals and objectives defining their reasons for participation in transfer efforts (5: 72). This literature review separated the organizations with technology transfer viewpoints into three groups. First, the academic or journalistic viewpoint is offered. This group has based their research on a more formal, scientific reasoning. Second, a more anecdotal set of organizational technology transfer objectives is provided by reviewing papers authored by participants in the Technology Transfer Society Meetings. Various organizational handbooks and mission statements concerning technology transfer were reviewed for technology transfer motives. These organizations' viewpoints are generally more practical, with emphasis placed on job accomplishment. Third, the viewpoint of congress is supplied.

Bozeman conducted research of 1,137 members of government laboratories involved with technology transfer to determine their organizational motive for involvement with technology transfer. The set of motives that Bozeman used in the research were:

1. Legislative requirements or statutory mandate.

2. Economic development emphasis of the laboratory.

3. Outgrowth of cooperative research and development, or research consortium.

4. Participation in industry-university or government-university research center.

5. Exchange of technical information or personnel.

6. Hope to increase the laboratory's parent budget.

7. Scientists' and engineers' personal satisfaction at seeing their ideas or technology developed.

8. Scientists' and engineers' interest in entrepreneur ship and personal wealth.

Bozeman's research revealed that most research organizations are involved in technology transfer because of the economic development benefits (4: 143; 50: 30).

Deonigi conducted similar research to that of Bozeman. The following are organizational motives for participation in technology transfer:

1. To transfer scientific knowledge.

2. To move technology into the next step/stage.

3. To encourage private sector investment or redirection of private research programs.

4. To obtain feedback from users.

5. To improve the nation's economic base.

6. To introduce a new technology to the end user.

7. To enhance/accelerate user acceptance and use.

8. To expand spin-off technology applications.

The results from the 147 cases suggested that most organizations thought that the objectives six and seven were the most descriptive of their organizations' involvement. Least relevant were objectives four and eight (51: 328-330).

Dakin argues that the role of technology and technology transfer is in the support of United States competitiveness on a global scale. Additionally, as a secondary objective, technology transfer is seen as a means to recoup a share of the federal investment in the technology development (25: 85). Other authors provide essentially the same set of technology transfer program objectives (16: 9; 24: 1; 39: 1; 52: 43; 53: 5; 54: 51; 55: 27).

Organizations responsible for conducting technology transfer have also implemented programs with stated organizational objectives for participation in technology transfer. Guilfoos operationalized General Yates' AFMC objectives as maximizing macro, socio-economic benefits to the United States economy (56: 176). Many other authors express their organizations' technology transfer objective as being enhancement of economics at either a local, state, region or national level and the creation of jobs (57: 293; 58: 301; 59: 340; 60: 357; 61: 364; 62: 395-401). Sayles provided the following as reasons for government to participate in technology transfer:

1. Satisfaction with the idea of participation in a breakthrough.
2. Benefits to society.
3. Inventors share in the royalties (63: 468-469).

The objectives of congress with respect to technology transfer are clear. Government laboratories, universities and industry are partners in United States technological competitiveness, implying creation of domestic jobs and global wealth. Congress views federal laboratories as a formidable weapon in the international competitiveness arena (50: 30). Bozeman would classify these as an economic development motive (4: 140). <u>The Stevenson-Wydler Technology Innovation Act of 1980, Public Law 96-480</u> stated findings that recognized the importance of technology transfer.

> 1. Technology and industrial innovation are central to the economic, environmental, and social well-being of citizens of the United States.
> 2. Technology and industrial innovation offer an improved standard of living,

increased public and private sector productivity, creation of new industries and employment opportunities, improved public services and enhanced competitiveness of United States products in world markets.
3. Many new discoveries and advances in science occur in universities and Federal laboratories, while the application of this new knowledge to commercial and public purposes depends largely upon actions by business and labor. Cooperation among academia, Federal laboratories, labor, and industry, in such forms as technology transfer, personnel exchange, joint research projects, and others, should be renewed, expanded, and strengthened. (64)

In general, all government organizations participate in technology transfer for one or more of the following reasons or objectives:

1. Legislative mandate from Congress.
2. Economic development for the country.
3. Political motivations.
4. Technological innovations.
5. Technology exchange.
6. Personal wealth.
7. Organizational wealth.
8. Recoup a share of the federal budget through lower cost, better technology.

Managed Process of Technology Transfer

The second part of the definition of technology transfer and one of Dakin's elements of a management is that of development and utilization of a managed process. A managed process is one that can be measured, controlled and improved by the manager (9: 1.1).

The state of the knowledge about technology transfer processes has expanded somewhat over the last eight years. In 1986, Dawson discussed nine models which he labeled technology transfer or innovation models. However, with the benefit of research available since 1986, it became evident that current researchers have been more successful in separating the technology transfer process from the technology development process.

However, Dawson's research did provide that the technology transfer process and technology development processes are subsets of the technology innovation process, even though models of that period did not as a whole accommodate this difference (24: 56-76). Hamner emphasized that definition and understanding of the applicable processes involved is critical to management of those processes (9: 2.8).

Dawson discovered that the technology transfer processes investigated were explanatory at best, and extremely complex. None of the models provided predictive capability. Just one of the models presented by Dawson had less than four stages involved. In fact, the Creighton Model, with just three stages, depicted the technology transfer process as a linking function between the source of knowledge and the utilization of knowledge. This linking function is essentially the same as current models presented later in this review. Many of the processes had as many as ten stages involved (Chakrabarti Model, Young Model). Even Creighton went on to provide nine more steps for his process (24: 56-76).

This review of the literature also discovered numerous processes used to transfer technology. In fact, one article showed seven separate methods to effectively move transfer from one organization to another (40: 5). The variety and complexity of the processes vary widely, yet all are less complex than the processes provided in Dawson's thesis.

Carr grouped all technology transfer processes into two generalized models; the legal or administrative model, and the marketing model. The legal/administrative model is based on programs run by the legal staff or the research and development centers. Emphasis is placed on technology development and then placement on the shelf. Government activity under this type of model is passive. On the other hand, the marketing model is an active technology transfer mechanism where centralized technology transfer offices market the technologies (16:15-16). Dorf essentially came to the same conclusions about the categories of technology transfer models (39: 5).

Weijo looked at the technology transfer process models in approximately the same manner. This research included passive models, role-directed models, and organization-directed models. Passive strategies aim to simply make the technology available to users with no substantive role on the part of the government. The role-directed process recognizes that certain roles must be played in technology transfer process. The organization-directed process focuses technologies on particular organizations in need of the technology (53: 44-60). Devine's categorization of the general process is essentially the same as that of Weijo, with different terms. Devine used availability model, dissemination model, and knowledge utilization model (55: 28). The Weijo and Devine models bear similar resemblance to both the Carr and Dorf models, in that there are active and passive process strategies. These are also referred to as technology push and market or technology pull.

All current technology transfer models can also be classified as either technology push or technology pull. Some organizations may use a combination of both in appropriate situations. Technology push moves innovative technology to a need in the marketplace. Technology push is active government, sometimes requiring funding by the technology transfer office or others. Market or demand pull starts in the marketplace, identifying a technology to solve a commercial requirement. Market demand technology transfer often implies less government involvement.

The marketing or active model is considered to be the most effective in terms of successful transfer (16: 16). Technology transfer systems are active by definition (24: 84). The marketing model recognizes that technology transfer relies on people in interacting roles and stages of activities aimed at promoting technology adoption (40: 5).

This research will focus on the marketing model as a baseline process due to its acceptance in the most current literature (5: 64; 2; 16: 15-16; 40: 5-6). Some examples of the marketing transfer process include several steps, such as the AFMC Science and Technology (AFMC/ST) model (56: 172-176). Spann, et al, were able to reduce a

majority of technology transfer process models, including marketing, to three basic steps: prospecting, developing and adopting (5: 64-65). This technology transfer process represents the most widely used method, and is typically considered a generalized marketing and active model (5: 63-64). Other marketing models can be described by this generalized model. For instance, the first three steps of the AFMC/ST process (develop strategy, identify assets, and market assets) can be reduced to the first step of the Spann model (prospecting). The fourth step of the AFMC/ST model (identify mechanism) can be compared with the second stage of the Spann model (developing). Finally, the fifth and sixth step of the AFMC/ST model (transfer technology and post-transfer administration) is like the adoption step of the Spann process.

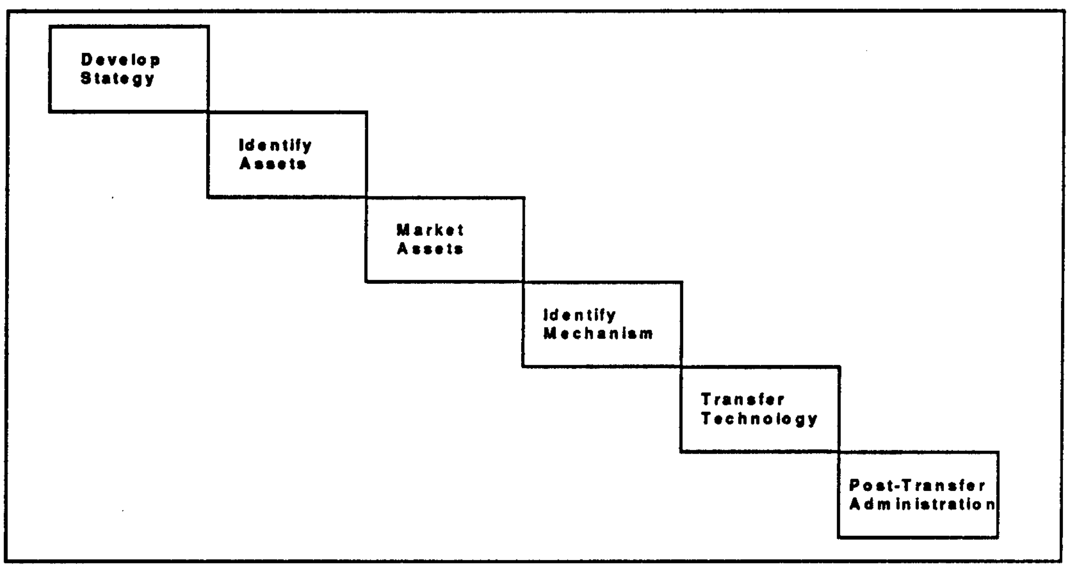

Figure 2.1 AFMC/ST Technology Transfer Process (56:173)

In the context of the generalized Spann model, the prospecting, developing and adopting stages have specific connotations. Prospecting is research, analytical and decision-making activities aimed at screening alternatives concepts or technologies and selecting the ones that fit the users needs. Key activities in the prospecting stage are screening, outreach, and conducting feasibility and economic impact studies. Developing

consists of physical and laboratory research and development activities focused on enhancing, tailoring and field testing specific technologies to meet requirements.

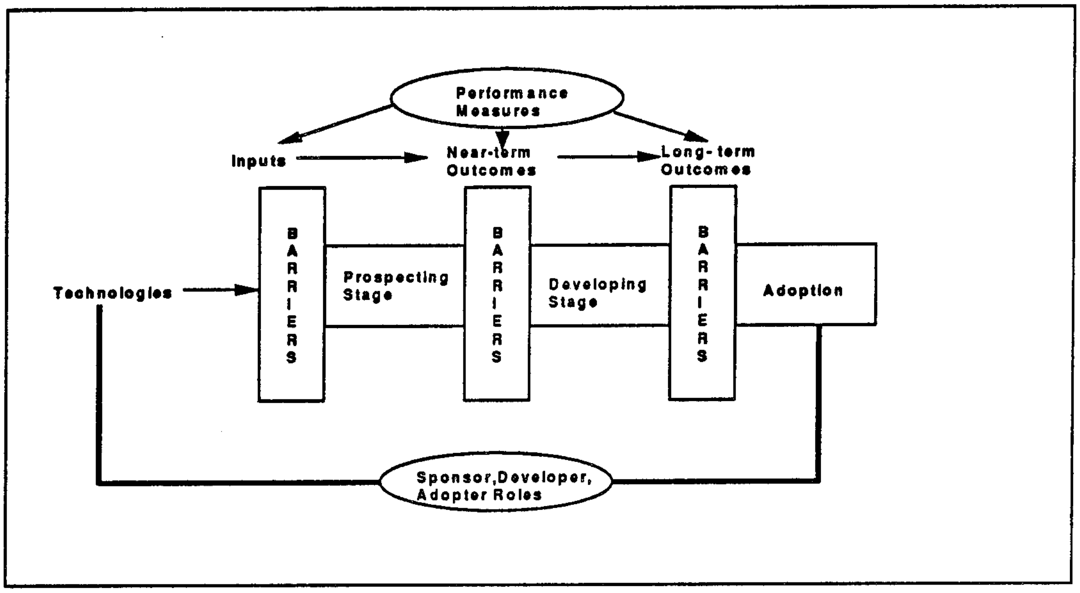

Figure 2.2 Spann, et al, Technology Transfer Model (5: 64)

A critical point in the developing stage is that the set of technologies has shrunk somewhat from the prospecting stage. The developing activities are focused on those technologies that survive screening. Specific efforts in the developing stage might include focused outreach between specific developers and a specific industry or business. The development stage might include specific application projects which validate the performance capabilities of the technology in a focused application, solving particular problems. Finally, the adoption, or spin-off, stage consists of final development and user implementation. This is where the technology transfer process achieves its objective -- final application of a technology in the commercial sector (5: 64; 40: 5-6). The time frame for proceeding through the technology transfer process can vary from short to long-term (5: 64; 65: 12).

Dawson, in the 1986 thesis, stated that technology transfer models were mainly passive and descriptive, not active and predictive (24: 87). This research was conducted prior to

1986 when the Federal Technology Transfer Act of 1986 and subsequent legislation mandated and incentivized active technology transfer. Active technology transfer has erupted since 1986, resulting in the popularity of the marketing model. Roessner emphasizes that managers should encourage the more individualistic, informal mechanisms of technology transfer as opposed to formal commercialization activities (52: 13).

The possibility for predictive, determinant capability is still unavailable, even though the desire is present (4: 143). Chapman believes the capability to sample and predict is critical to completely transform technology transfer to a managed process (3: 165).

Geisler conducted research on the independent variables involved with technology transfer in an effort to become predictive about success. His hypotheses included:

> Hypothesis 1: Organizational variables of level of effort in commercialization activities, support from top laboratory management, and previous experience of the lab in commercialization, will be positively associated with the success of the technology transfer effort.
> Hypothesis 2: Individual variables of technical capabilities, intrapreneurial attributes towards commercialization will be positively associated with the success of the technology transfer effort. (66: 64)

Geisler's results from this research are not yet available, but the study certainly charts a desired course for predictive, dependency models (66: 65). Baily examined the possibility that technology transfer success may be related to the profile of the company involved as the user. This research represents another attempt to apply deterministic, causal relationships to the success of technology transfer (67: 151).

Technology Transfer Roles

Technology transfer is a person to person phenomena. It is more like a basketball game where the team passes the technology back and forth until a score is made, than a relay race, where the baton is passed and the runner stops and cheers for the next runner (16: 9; 51: 334; 52: 9). When considering the marketing model, technology transfer

must be performed by people. Understandably, these people take on different roles in the technology transfer process similar to those played in any successful business venture.

Robert Reich classifies all businessmen into three categories: problem-solvers, strategic brokers, and problem-identifiers (14: 84-85). This model can be directly transformed into a technology transfer case. Problem-solvers are those people who develop technology. Problem-identifiers tie the technology to specific applications. Strategic brokers are those people in the middle who make the relationship between the problem-solvers and problem-identifiers work. Souder applies transfer names to these roles as developer, implementor, disseminator, and sponsor (40: 7). Dawson categorizes technology transfer agents as sourcer, user, and gate-keeper or linker (24: 84). Spann reduces Souder's four roles to just three: developer, sponsor, and adopter (5: 64).

Developers develop and apply technology under government or private sponsorship. Sponsors fund technology development, disseminate information, perform outreach activities and broker the interaction between the developer and the adopter. The adopters are users or potential users of the technology. They might range from individuals to industries (5: 64).

Technology Transfer Success Metrics

The nation will invest nearly $70B in FY95 in Federal laboratories (68: 6). The nation will spend over $1B in FY95 for defense conversion, dual-use technology, and technology transfer programs such as the ARPA Technology Reinvestment Program (TRP) and the NIST Advanced Technology Program (ATP) (32: 8). Individual organizations will invest millions of dollars in manpower and funding in technology transfer processes during FY95 (8).

Federal technology development and transfer organizations are facing the growing perception that the nation is not getting ample return from its research and development budget. There is growing national demand for measurable results from the investment in

technology (16: 8; 11: 13; 69: 1-2). A complete session of the 19th Technology Transfer Society Meeting in Huntsville was devoted to technology transfer measurement with six papers presented. The AFMC Technology Transfer Working Group has devoted portions of its agendas to technology transfer metrics. A separate working group has been established to determine the best series of metrics to use to measure AFMC technology transfer.

Metrics are the mechanism to keep a process in control (9: 2.1). An organization should establish its technology transfer goals and objectives and then establish metrics and measurements to evaluate the progress (5: 72; 51: 327; 9: 2.6). Very few organizations are able to track technology transfer successes and metrics to the original objective for involvement in technology transfer (5: 327). Attributes of a good metric are:

1. It is timely.
2. It drives the appropriate action.
3. It is repeatable and shows a trend.
4. It encompasses a controllable activity.
5. Its data is economical to collect.
6. It is accepted as meaningful to the customer.
7. It is formulated at a critical point in the process.
8. It is unambiguously defined.
9. It tells how well organizational goals and objectives are met through processes and tasks (9: 2.3-2.4).

Barriers to Measurement

It is difficult to answer questions from congress as to how effective the technology transfer efforts within the federal government have been since the mandates of the 1980s. The main reason for the difficulty is that limited effort has been devoted to developing

technology transfer metrics (16: 19; 69: 1-2). Those that have tried to measure the effectiveness of technology transfer have had limited success (11: 14). Traditional measures, such as licenses granted or royalty income, are incomplete and do not satisfy the questions being asked. Unfortunately, the results congress demands are the hardest to gather. These metrics just measure the value of the technology, at the expense of measuring the value of the technology transfer process too. There exists a growing requirement to establish a set of comprehensive metrics that measure the value of the technology transfer process itself, as well as the value of the technology input to the process (69: 2).

Technology transfer success is difficult to conceptualize and define. The evaluation of the technology transfer process depends upon this definition of success. Successful technology transfers can range from simple infusion of a technology into an organization for future use, to immediate incorporation of the technology into an existing product or process. There are many combinations of outcomes from the technology transfer process, all of which could be classified a success, depending upon the mission of the organization (70: 15-16; 16: 19; 1: 345; 4: 141-142).

Technology transfer can assume a variety of, or multiple missions within an organization. The ultimate determination of the technology transfer mission depends upon the mission of the organization itself. For instance, federal laboratories charged with the primary mission of development of technologies for next-generation military weapon systems may see technology transfer as a secondary, or lesser, mission. The definition of successful technology transfer in this organization would be different than in an organization where technology transfer is a primary mission. Technology transfer success metrics must measure the value of the technology transfer process, as well as the value of the technology itself, even when technology development is the primary mission of the organization (69: 4; 11: 15-16; 4: 141-142).

Technology transfer sponsors manage the technology transfer process. They generally do not have control of the technology development stage, nor the eventual commercialization stage. Many factors fall outside of the control of the technology transfer office. Rarely are technology sponsors or end-users consulted by developers about methods to focus on-going or proposed technology development to enhance commercialization opportunities, although the frequency is increasing (23). Additionally, the technology transfer office is not explicitly involved with marketing, production or sales of products resulting from the technology. In recent solicitations, government agencies are requesting proposed business plans as part of the defense conversion awards, but these plans do not guarantee commercialization will transpire (71: 2). Generally, technology transfer sponsors are in control of the technology transfer process, and rely on infusion of good technology from developers and sound business decisions by commercial partners (4: 141-142; 69: 3-4; 50: 31; 11: 14-17; 56: 174).

The value of a metric is that it helps steer an organization. In order to obtain information to adjust the path of an organization timely, readily available data is required. Certain data on economic impact is not available for ten to fifteen years. Technology may be infused into an organization and eventually transform a product, or be combined with other technologies to generate a new product. The data is hard to gather. If it can be gathered, it may be competition-sensitive and not readily releasable to the government (11: 17; 1: 345; 69: 3-4; 72: 2; 47: 114).

Current Methods of Evaluating Technology Transfer Success

What value was produced and how was it used (11: 13)? Current technology transfer metrics are comprised of qualitative metrics which are anecdotal in nature, as well as some quantitative metrics. Due to the difficulties in accurately measuring technology transfer effectiveness, both types are required (69: 8; 4: 138; 16: 20). Discussions of the current

thoughts in technology transfer metrics must be framed in the context of the technology transfer mission of the organization.

Qualitative Measures. Measurement of technology transfer should not be limited to one type of metric. Quantitative, anecdotal success activities should be tracked to provide a complete measurement. Measures of this type are good sources to evaluate and improve adopter satisfaction. Customer surveys, testimonials, and case studies are common qualitative methods to identify technology transfer success (16: 20; 69: 8).

Quantitative Metrics. Bozeman has provided a bridge between the mission of an organization with regards to technology transfer and the metrics used to steer the organization in that facet. The four categories of metrics used are:

1. Out-the-door model.
2. Market-impact model.
3. Political model.
4. Opportunity-cost model (4: 141-142).

The out-the-door model of measuring technology transfer considers only if the technology got transferred to a different organization. This concept focuses on the transfer itself, not the impact of the transfer. The data for the out-the-door model is relatively easy to collect and focuses on activities that are under the control of the technology transfer organization (4:141-142).

The market-impact model focuses on the commercial impact of the technology transfer to the gaining organization. This measure is more meaningful but much harder to collect. A greater share of the activities involved with this measure lie with the using organization. The technology transfer organization can facilitate the transfer only to a certain point, and then the commercial user must create a spin-off. Measures of this sort are more appropriate for long-term evaluation purposes, as opposed to short-term metrics for

controlling an organization. A variant of the market model considers the impact of technology transfer on the laboratory or research facility itself, as in royalties (4:141-142).

The political model of technology transfer measures the amount of political attention that is gained by involvement in technology transfer. This has become a more widely used metric in the past few years, especially with the increasing attention from the Clinton Administration on federal technology transfer (4:141-142).

The opportunity cost model focuses on the comparison between the trade-offs of other activities that the funds used to support technology transfer could be used for. This model is essentially a cost-benefit type relationship with the assumption that the technology transfer has benefits that off-set the costs (4: 141-142).

Spann built on the research of Bozeman by classifying the four models presented into those supporting active, technology push strategies, or those supporting passive, technology pull strategies. The out-the-door, political, and opportunity cost models each support the notion of technology push. Technology push focuses on making the technologies available and measuring such things that are input related. These include metrics such as number of licenses, technical papers, technical presentations, responses to requests for help, site visits, time spent on transfer, and transfer budgets. All of the technology push metrics are in the control of the transfer organization. Market-impact models support technology or market pull transfer. Measures are related to the perceived needs of the United States economy and industries in that economy. Transfer outcomes are measured in macroeconomic terms such as jobs created or businesses created (69: 6).

Other authors also discussed the time dimension of technology transfer measurement. Technology transfer is often a long-term, multi-stage process. This research supported measuring transfer effectiveness over periods of immediate (one year), intermediate (two to four years), and long-term (five or more years). This supports the notion of previous discussions that immediate and intermediate metrics might be used to control and steer the technology transfer process, whereas the long-term measures might be used to evaluate

the technology itself with respect to commercialization opportunities. In the near-term, it is important to develop a means for tracking potential technology transfer opportunities, concentrating on a combination of input measures. By capturing the near- term data, the technology transfer organization can continue to follow-up throughout the intermediate and long-terms. Near-term data is generally input related including such things as number of personnel assigned to the office or technology transfer budget. This data is widely regarded as unsatisfactory because of its poor translation to products or accomplishments. In the mid-term, measurement should be focused on intermediate products, such as CRDAs, other types of agreements, and outreach activities. These measures should indicate that the technology transfer organization is building upon the opportunities created and discovered in the near-term evaluation. In the long-term, technology transfer organizations should concentrate on those measures which indicate satisfaction of the organizational technology transfer and other goals. These might include products or enabling steps to a product (69: 5-6; 11: 17-18; 47: 114; 72: 5).

Research conducted by Spann in 1993 indicated measures differ depending upon what role one plays in the technology transfer process. Developers, sponsors and adopters disagree on what measures to use. Developers tend towards strictly input measures such as technical papers. Sponsors use numbers of technical problems solved and new products created. Adopters usually favor the long-term macroeconomic measures such as productivity gains, competitive advantage gains, and new products. Sponsors took a more balanced view of measurement (5: 68-71).

The relationship between input and output metrics are more likely to capture the interests of the sponsor role. Additionally, sponsors spend more time defining success, measuring success itself, and reconciling success with the organizational missions. The relationship between the objectives of a government organization's involvement in technology transfer and applicable measures is detailed in the following table:

TABLE 2.2

ORGANIZATIONAL OBJECTIVES VERSUS MEASURES OF TECHNOLOGY TRANSFER (5: 70: 4:143; 51: 328-330; 25: 85)

ORGANIZATIONAL OBJECTIVES	MEASURES
Legislative Mandate from Congress Political Reasons to show Compliance or to Obtain Budget Technology Exchange	Input: Transfer Expenditures Transfer Budgets Time spent Request for help Site visits
Political Technology Exchange Personal Satisfaction with Technological Innovation Personal Wealth for Scientist Organization Wealth through Royalties Recoupment of Federal Dollars by Lowering the Technology Cost	Near or Intermediate Term: Technical papers Technical presentations Patents Agreements Success stories Technical problems solved Project milestones
Economic Development for the Nation Personal Satisfaction with Technological Innovation Personal Wealth for Scientist Organization Wealth through Royalties Recoupment of Federal Dollars by Lowering the Technology Cost	Long Term: Return On Investment Cost savings Productivity Royalties Competitive advantage gains Market share gains New commercial sales Number of new products New commercial customers User satisfaction Jobs created

Summary

This chapter focused on the current technology transfer literature. Specific areas of investigation were technology, laws, motives, processes, roles, metrics, barriers and current methods to measure technology transfer. Chapter Three will focus on the research methodology.

III. Methodology

Introduction

The objective of this research is to provide a case study of how one government laboratory -- Wright Laboratory (WL), Wright-Patterson Air Force Base, Ohio -- controls its technology transfer program. This chapter outlines the process by which the primary data was collected to address the research objectives through a case study methodology. This chapter addresses research design, research population and sample, case study question development, interview development, data collection and analysis, and methodology design limitations.

Background

Chapter Two provided a detailed investigation of technology transfer. Although there has been much written with regard to technology transfer, little formal research has been conducted, especially concerning measurement (69: 2). Research that has been accomplished is at an exploratory level. This research continues investigation of technology transfer in an exploratory fashion by using current literature and elite personal interviews.

Research Design

Emory and Cooper describe exploratory studies as particularly useful when the researcher lacks a clear idea of the problems that will be uncovered during the course of the study. The areas of investigation may be so new that a researcher needs to perform an exploration just to learn something about the problem (6: 144-145). Technology transfer objectives have been investigated by only a few researchers. Technology transfer metrics have not been frequently researched, although the popularity is increasing (11: 1). Therefore, this research fits the exploratory mold offered by Emory and Cooper due to the lack of crystallization of the technology transfer subject (6: 140).

A logical first step in an exploratory study was a literature review. The literature review provided a background in the area of interest and provided several leads for the research focus. The availability of current literature on technology transfer provided a general overview of the subject. Over the last year the topics have become more popular in the Journal of Technology Transfer and at the Technology Transfer Society meetings. However, limited literature and research existed for the specific topics of technology transfer motives and success metrics, and even less for the more complex relationships between the two at various levels in the organization.

Exploration of the literature provided leads for further investigation. As a result of these leads, experts in the field of technology transfer metrics and industrial base economics were interviewed at the 1994 Technology Transfer Society meeting in Huntsville, Alabama. These interviews provided focus as to current thought and aided in steering this research. The results are provided in Chapter Two. Emory and Cooper view personal expert opinions as an ideal method to seek ideas about the important aspects of the subject (6: 145-146).

The complexity of the research question warranted utilization of an exploratory case study methodology. A strength of exploratory studies is in research that delves into complex relationships. Exploratory studies emphasize the respondents' frame of reference and context of the situation, which can not be adequately captured in surveys (73: 46). Case studies are meant for depth, as opposed to breadth. They rely on qualitative data from a limited number of sources. They are not often meant to be generalized to the greater population (6: 142-143). Yin distinguishes among three types of case studies: exploratory, descriptive, and explanatory. Exploratory case studies, which represent this research, are used as a basis for formulating more specific questions, providing lessons learned, and generating hypotheses (74: 17).

Research Population and Sample

The population applicable to this research consisted of government organizations with a technology transfer mission. Unit of analysis was the organization hosting the technology transfer unit or department. The primary emphasis of the case study interviews were focused towards technology transfer sponsors within the organization as recommended by Spann (5: 64). However, interviews with members of other parts of WL were also conducted to provide additional insight (74: 41).

From the population of government organizations with technology transfer missions the researcher chose a sample size of one, which is typical for case study research (6: 142-143; 74: 50). The organization studied was WL at Wright-Patterson Air Force Base, Ohio. The sample was purposeful and judgmental. WL fit the requirements of the sample and was a typical research facility within the government laboratory network (6: 273; 75: 102). The WL Office of Research and Technology Applications (ORTA) belongs to the Air Force Material Command (AFMC) Integrated Product Team (IPT) for technology transfer, and is knowledgeable on the topic.

Research Instrument Development

Data was collected through personal interviews with members of WL and through analysis of organizational documents. Gummesson considers the use of both oral and written transmission of data as critical in case study work in order to obtain the complete picture of an organization (76: 104).

Focused elite interviews were conducted in an unstructured fashion, utilizing open-ended questions. Focused interviews in case study research are of benefit when the researcher desires to follow a specific question vein, searching for corroborating facts (74: 89). Elites are selected based on their experience or knowledge of the study topic. Elite interviewing provides valuable information due to the position of the elite. Of

particular importance to this study was the ability of elites to transform efforts within their own unit or department to efforts of the organization as a whole.

The primary disadvantage of elite interviewing stems from the most significant advantage. The respondent tends to understand the study topic well enough to challenge the interviewer. The literature review has prepared the researcher to search for answers that will categorize the organization. This method, outlined by Gummesson, permitted the researcher to concentrate on those areas of importance to the study topic without transcribing all portions of the interview (76: 106; 75: 106).

The second type of data collection was through analysis of records and documents within the WL organizations. This type of data collection is valuable in previously undefined areas of research (73: 94-96; 74: 85).

Question Development. Question topics were developed through the literature review conducted in Chapter Two. Question topics that were applicable to the ORTA, adjunct members of the ORTA and WL management were addressed to all groups. Some questions related specifically to one group or another. Interview questions are presented in Appendix B. A matrix depicting the strategy of question delivery and the expected form of data collected is presented in Appendix C.

Construct validity was maintained in three ways. First, interview questions were developed based on review of literature and experts' opinions. Second, the instrument was pilot-tested with a member of the National Aero-Space Plane (NASP) Technology Transfer IPT (74: 80-82). Finally, multiple sources of evidence were used to corroborate the oral interviews (74: 41).

Data reliability was ensured in two ways. First, was the development of a repeatable case study protocol presented in Appendix C (74: 70-80). Second, data reliability was ensured through careful documentation of question development and interview techniques, and maintaining a chain of evidence. This will be discussed under interview techniques and data analysis (77: 3-5; 74: 102).

Interview Development. The researcher considered interviewer training, interview technique, data recording and pre-interview efforts during the development of the interview.

Interviewer Training. To become more accustomed with the questionnaire and to resolve issues, the interviewer pre-tested the instrument with a knowledgeable individual (74: 80). Lessons learned from the pre-test were documented and incorporated into the interview technique and research instrument. Additionally, Yin has provided a complete chapter on preparing for data collection (74: 61-83). The interviewer has had experience in case study interviews while working with the Air Force Systems Command (AFSC) Inspector General (IG) Team.

Interview Technique. Interviews were conducted in the offices of the respondents to maximize comfort. Respondents were extended the choice of a telephone interview versus a personal interview. All interviews were conducted by the researcher. Questions were asked in the same order for each respondent to minimize any bias due to ordering. However, in order to optimize the benefit of interviewing, some questions were altered between interviews to allow for clarity and precision (74: 89-92).

Data Recording. Data was recorded by the interviewer. Emphasis was placed on collecting only pertinent information, not on transcribing the complete interview (74: 91). Follow-up interviews were utilized to clarify facts that the interviewer may have mistook.

Yin recommends the use of a tape recorder during the interviews. However, the device should not be used if the respondent refuses permission, there is no plan to use the tapes, the recorder creates an extreme detraction, or the researcher reduces his care during the interview because it is being taped (74: 91). Due to the fact that this research was conducted alone, a tape recorder was required to maintain a comprehensive compilation of the questions and answers. This back-up system was used to verify that the information transcribed by the interviewer was correct. Respondents were given the option of refusing to allow a tape recorder in the session, and provisions were made to have a back-up

recorder available. The interviewer explained to the respondent the purpose of the tape recorder and the respondent was ensured that the tapes would be destroyed at the conclusion of the research.

Non-Attribution statement. The researcher included a non-attribution statement at the beginning of each interview. Respondents were assured that the research was a documentation of a case and not an attempt to determine fault.

Pre-Interview. In an effort to familiarize the participants with the research effort, the researcher briefed each respondent prior to the start of the study about the objectives and desired participation. Copies of the draft literature review, questionnaire and question matrix were provided to WL before the case study began to facilitate the interviews.

Data Analysis

The case study is a readable, descriptive picture of the unit of analysis under research (75: 299-306). The data analysis procedure for the case was adapted from a thesis by Khuri and Plevyak. These researchers include data examination, data categorization and data evaluation in their data analysis procedure (77: 3-9).

The raw data collected from the interviews was reduced to a more manageable format provided in Appendix D. Data evaluation included condensing and grouping the data into issues. Relative importance of the issues was based on frequency of response (74: 102; 77: 3-9).

Limitations of the Design

Methodology design limitations are grouped into research bias, interview limitations, case study protocol, and data reduction errors.

Research Bias. Personal interviews are simply verbal recollections of the past, and are subject to research bias such as poor recall and inarticulate descriptions (74: 91). Respondents were limited to answering questions during a period of one hour with respect

to activities that have occurred over a period of several years. Additionally, the number of respondents was just nine, stemming from an elite field, which renders the non-attribution safeguard meaningless. Hence, respondents might have been on the defensive to give acceptable answers, as opposed to accurate answers. Finally, recent efforts by the AFMC technology transfer working group and the availability of the draft literature review from this research may have unwittingly educated the respondents to the issues of technology transfer control.

Interviews. The interview technique was limited by the existence of just one interviewer with bounded experience. Additionally, some questions were never quite as clear as intended, and the interviewer was required to explain them in different terms. Finally, the tape machine may have been a distraction, even though it was critical to the data collection efforts.

Case Study Protocol. The case study protocol was limited in that some of the questions could have been asked to wider set of respondents.

Data Reduction. Bias may have been introduced to the research during data reduction. The interviewer listened to the tapes a number of times, yet some answers were still unclear and judgment was required to interpret the data. Additionally, the tape machine worked improperly during one interview, and a few seconds of data were lost.

Summary

This chapter presented the research design, research population and sample, question development, interview development, data analysis, and methodology limitations. The method of collecting qualitative data was through focused elite interviews and review of documents in the WL ORTA. The data was analyzed through construction of a case study. Chapter Four presents results from the data collection effort.

IV. Results

Introduction

The objective of this research is to provide a case study of how one government laboratory -- Wright Laboratory (WL), Wright-Patterson Air Force Base, Ohio -- controls its technology transfer program. Research objectives are as follows:

1. Determine the motives for WL involvement in technology transfer.

2. Determine the technology transfer process in WL.

3. Determine measures used to assess the success of the technology transfer program.

This chapter discusses the data collected during the elite personal interviews with personnel in WL. The case study is discussed through two main areas. First, the method of analyzing and presenting the data is provided. Second, the data is discussed with respect to the categories of technology transfer process, organizational objectives, and technology transfer success metrics.

Data

The summary of the raw data is presented in Appendix D. Data was organized within a matrix of categories (74: 106). The data was reduced from the notes of the interviewer and the tapes used during the interviews. In Appendix D respondents were categorized into three areas for presentation and analysis (74: 106). First, WL management consisted of those respondents involved with general technology transfer policy at the laboratory level. Second, technology transfer focal points are those respondents who work with the technology developers in each of the technology directorates. Finally, members of the Office of Research and Technology Applications (ORTA) are those respondents working in the ORTA responsible for the day-to-day management of the technology transfer program in the WL. The case study is organized and presented in this manner to permit

analysis in terms of the theoretical proposition that technology transfer is controlled by WL (74: 106-107).

Technology Transfer Process

Through the personal interview respondents classified the technology transfer process used within WL. Areas of the technology transfer process discussed are provided in Table 4.1 (77: 4-2).

TABLE 4.1

TECHNOLOGY TRANSFER PROCESS

Technology Transfer Process Strategy
Technology Transfer Mechanisms
Communication Methods
Technology Transfer Incentives

Technology Transfer Process Strategy. Spann and Souder presented the elements of an active technology transfer process as screening technologies for commercial potential, marketing those technologies, and pursuing activities to facilitate transfer (5: 64; 40: 5-6). The interviews were conducted to determine if the elements of an active technology push organization were present.

In general, the screening of technologies for potential commercial applications is inconsistent within WL. There were significant pockets of activity within the organization that did perform these tasks, but others organizations did not participate in screening efforts. Two organizations had built commercial applications screening into their technology acquisition and development process. They termed this the technology

transfer road map and considered both scientific and economic feasibility proofs during screening (25: 38-39). One of these two organizations had went as far as suggesting that technology development was planned to maximize both commercial potential and military application. The ORTA had also linked with a National Aeronautics and Space Agency (NASA) Regional Technology Transfer Center (RTTC) during FY94 to perform a joint effort using graduate students from Wright State University to screen technology. Most significantly, all participants recognized the importance of screening technologies early and then focusing continuing WL efforts on those technology areas.

Marketing and outreach was performed consistently within the laboratory. Both formal and informal methods of marketing and outreach were used. However, the activity was generally conducted on a wholesale approach of the complete menu of laboratory technology, as opposed to focusing on those technologies that survive the screening process. One organization had built marketing into the technology road map using focused target discussions and multiplier groups to generate potential avenues for technology transfer applications. In general, the other organizations used Wright Technology Network (WTN) as the means of marketing and outreach. The laboratory, along with WTN, uses such things as advertising, conferences, symposiums, displays, articles, brochures, newsletters, the Internet, and Commerce Business Daily as a formal means to market the technologies. Most respondents realized that WL Directorate of Operations (WL/DOR) was responsible for marketing for WL, but admitted that individualized marketing of technologies was important outside the responsibility scope of DOR. The respondents also recognized the importance of person to person activity by encouraging informal word-of-mouth marketing between developers and adopters.

Respondents classified the WL technology transfer strategy as a combination of both technology push and technology or market pull. It was generally believed that the strategy depended upon the technology, as well as the technologist. For instance, some technologies are easily marketed and applied in the commercial world. As well, some

technologists have skills that are conducive to technology transfer. Whereas other technology areas and technologists are better suited for passive market pull, such as answering requests for help and technical questions. Two organizations have included the market needs in the technology development road map.

The participants were mixed about the inclusion of contractor developed technology in WL technology transfer efforts. Some organizations included those technologies and supported the transfer activities. Others felt it was the responsibility of the developing contractor to perform the transfer efforts. All respondents were concerned about the intellectual property rights of the technology developed by the contractors.

Technology Transfer Mechanisms. Technology transfer is a person to person process where most transfers occur through informal methods (16: 9; 51: 334; 52:9; 52: 13).

Respondents were very consistent in discussing the mechanisms used by WL to facilitate technology transfer. All participants recognized that both informal and formal mechanisms must be used. The mechanism is dependent upon the technology, technologist, and the adopter involved with the transfer. All recognized that informal mechanisms are responsible for the majority of the transfers. However, they did discuss things such as patents, technology development contracts, licenses, and Cooperative Research and Development Agreements (CRDA)s as another small means to facilitate transfers. In general, the respondents believed that utilization of existing networks and development of new networks was the most predominant and successful method to transfer technology.

Communication Methods. The focus of discussion with respect to communication methods centered on the methods to obtain feedback from the technology adopters during and after the technology transfer. The general feeling of the respondents was that an informal communication link was maintained through a network of mutually interested developers and adopters. Some organizations mentioned the final report required at the

conclusion of the CRDA. Other organizations mentioned that the developer and adopter are tied together via contractual mechanisms and are required to communicate. The consensus of the respondents was that although communication was encouraged during the transfer, follow-up communication after the transfer was somewhat of a luxury.

Technology Transfer Incentives. The focus of this area was of incentives for WL personnel to transfer technology. The predominant method to incentivize transfer activities was the awards program that existed within some directorates. One respondent mentioned the possibility of receiving royalty income. One other respondent mentioned the position descriptions used for scientists and engineers and evaluations for promotions. Some felt that awarding technology transfer may be seen as a bribe.

Organizational Objectives

During the personal interviews respondents were asked to discuss motives for participation in technology transfer. Table 4.2 presents the general areas of discussion under organizational objectives.

TABLE 4.2

ORGANIZATIONAL OBJECTIVES

Wright Laboratory Mission
WL Technology Transfer Objectives

Wright Laboratory Mission. All respondents clearly designated the primary mission of WL as development of technology for military systems. One respondent mentioned technology transition to System Program Office (SPO) aircraft. A management level person thought technology transfer was also a primary mission of the laboratory in addition to technology development for aircraft.

WL Technology Transfer Objectives. In an effort to obtain the motives for WL participation in technology transfer the respondents were asked to discuss why they pursued technology transfer activities. The responses were split between national and local economic reasons, political reasons, regulatory reasons, technology cost motives, and personal motives. Several respondents felt that the creation of jobs, the revitalization of American industrial base, and the preservation of American preeminence in a particular technology base were the primary reasons for involvement in technology transfer. Other respondents felt that WL participated in technology transfer simply for regulatory reasons. If the regulations were disbanded, technology transfer activities would stop, or at least slow down. Some respondents saw the connection between commercialization and the cost, performance and availability of the technology. They believed that active commercialization promoted lower cost products and made the technology available for more people to use, including the defense industrial base. Finally, one respondent felt that the potential to receive royalty revenue was the primary motive for participating in technology transfer.

Technology Transfer Success Metrics

During the interviews the subject of measuring technology transfer was discussed. Specific areas of focus are provided in Table 4.3.

Definition of Technology Transfer Success. Respondents discussed the definition of a successful technology transfer activity. The majority of the participants were very clear in that they believed successful technology transfer occurred when a product or process was moved into the commercial sector. A technology product or process was defined by the respondents as information, technical knowledge, hardware or data. Additionally, one person expanded the definition to include helping commercial companies by reducing their research and development burden. Just one respondent thought that creation of jobs in the commercial sector adequately defined successful technology transfer. One person felt that

gauging the satisfaction of the internal and external partners in a transfer agreement was the discriminator of a successful technology transfer activity.

TABLE 4.3

TECHNOLOGY TRANSFER SUCCESS METRICS

Definition of Technology Transfer Success
Near-term Metrics
Long-term Metrics
Data Collection Mechanisms
Barriers to Measurement

Near-term Metrics. Respondents provided a mixed set of answers in response to the discussion area of tracking near-term measures of success of the technology transfer process. Several groups believed that there was no current practice of measuring day-to-day technology transfer within WL. Some groups maintained metrics within their organizations, tracking items such as phone calls for technical information, documents delivered, and outreach activities. These groups did not routinely advertise that these personal metrics were tracked. The metrics were not provided to the command section. Some organizations kept anecdotal, qualitative metrics such as descriptions of the technology transfer activities. Again these were tracked at the organizational level. Nearly everyone interviewed knew of the emphasis placed on counting CRDAs. However, everyone also suggested that CRDAs represent a small portion of the ongoing activities.

Long-term Metrics. In response to the discussion of long-term success metrics for the WL technology transfer program the participants' opinions were varied. Nearly all respondents said there was no official way of tracking the effectiveness of the technology

transfer program within WL. A few members of the WL technology transfer team believed that economic impact to the commercial sector was the best method. However, a majority of the people thought that the revenues back to the laboratory through royalty income represented the best metric. One participant mentioned the spin-back value of increased data on the technology and advancement in the technology due to commercial applications as the appropriate criteria to measure effectiveness. Just one person mentioned CRDAs and patents as a good long-term metric. Finally, one respondent believed the continued existence of WL as the way to determine if technology transfer efforts were successful.

Data Collection Mechanism. Respondents were asked to discuss the mechanisms to collect benefit data resulting from their technology transfer efforts. Essentially everyone believed there was no official or sponsored method to collect success data. Most felt that they were limited by time constraints, and that data collection was a luxury. Others believed that data collection was limited by significant barriers. Some organizations did solicit feedback through written and telephone surveys. The main method discussed, however, was informal links with industry.

Barriers to Measurement. Nearly everyone on the WL technology transfer team believed there to be significant barriers to measurement of technology transfer. These generally revolved around data collection problems. Time appeared to be a big constraint in data collection. Some organizations, both government and commercial, do not have time to follow up on transfer activities. Additionally, the development of successes may take years. The people involved in the original agreement may change jobs, forgetting the origins of the technology. As well, feedback is difficult to obtain for many reasons other than time. Some data may be competition-sensitive. When feedback is provided one has to question the validity of the information, especially in the area of economic benefits.

Other barriers include understanding and utilizing the WL technology transfer process. Some felt that the technology process was difficult to understand and not bench marked

within the laboratory. Therefore, they believed measurement to be impossible. Others felt that the objectives and motives for WL involvement in technology transfer were unclear, and hence measurement is difficult. Finally, there does not seem to be a consistent definition of a successful transfer within the laboratory.

Discussions also focused on the measurements themselves. No one measure does everything. The current CRDA measure is only a small portion of the entire technology transfer picture. As well, measuring technology transfer is time consuming and may take more effort than the technology transfer activity itself.

Summary

This chapter presented and discussed the results of the case study methodology. Areas discussed were data presentation, the WL technology transfer process, WL organizational objectives for technology transfer, and technology transfer success metrics. The data was discussed in this manner to facilitate appropriate analysis along the theoretical proposition that WL controls its technology transfer process. Chapter Five will provide conclusions, recommendations for future research, and a thesis summary.

V. Conclusions and Recommendations

Introduction

This chapter offers conclusions on the control of technology transfer within Wright Laboratory (WL), recommendations for future research opportunities, and a thesis summary. The conclusions will suggest answers to the research objectives presented in Chapter One and discussed throughout the research. Specifically, the conclusions will discuss the technology transfer objectives of WL, the technology transfer process that is used within WL, and the metrics used by WL to measure technology transfer success. Particular attention is paid to linking the three research objectives into the way WL controls technology transfer.

Conclusions

Specific conclusions about the research objectives have been drawn from the interviews of participants in the WL technology transfer team and are included in Table 5.1.

TABLE 5.1

RESEARCH OBJECTIVE CONCLUSIONS

1. There is no consistent technology transfer motive within WL.
2. The elements of a modified technology push process model are present in parts of WL.
3. WL uses resources invested in Cooperative Research and Development Agreements (CRDA)s and the number of ongoing CRDAs as the principal method to track the effectiveness of their technology transfer process in the near-term.
4. WL uses qualitative success stories to track long-term effectiveness of their technology transfer process.

__WL Technology Transfer Objectives.__ There is no consistent technology transfer objective for WL. Essentially all participants believed the primary mission of WL was development of technologies for weapon systems. All but one respondent placed technology transfer as a secondary, lesser objective of the laboratory. The primary motive for WL involvement in technology transfer was economic impact on the local, state, regional and national economy. Confounding this conclusion is the fact that the economic motive may be simply in support of a greater political motive. Either of these motives are acceptable in accordance with Bozeman, but the importance of designating either an objective or a set of objectives can not be overstated (4: 143; 5: 72).

__WL Technology Transfer Process.__ The elements of an active modified technology push process are present within different pockets of WL (16: 12). The technology transfer strategy within WL is a combination of technology transfer push and technology transfer pull. This combination is appropriate for a laboratory the size of WL, and the diversity of the technologies and technologists within WL.

__WL Technology Transfer Success Metrics.__ WL is tracking near-term and long-term metrics in an effort to gauge the success of their efforts.

__Near-term Metrics.__ The consensus of WL personnel is that the near-term metrics consistently tracked are the resources invested in the CRDA and the CRDA count. A majority of the participants recognized that these metrics are inadequate. Tracking CRDAs is a result of the recent guidance from the Technology Transfer Office (TTO) to utilize CRDAs in this capacity (78). CRDAs, although easy to count and track, are not a large portion of technology transfer activity. The CRDA count is of questionable contribution to assessment of the efficiency and effectiveness of the technology transfer activities, unless the WL objective is to just produce CRDAs. The majority of technology is transferred without the use of formal agreements (52: 13). Information drawn from the CRDA number is not indicative of the complete technology transfer process and should not be used exclusively for decision-making purposes (control). A metric must also drive

the appropriate behavior (9: 2.3). By working to establish formal agreements such as CRDAs, WL is actually deterring technology transfer. Deonigi and Bozeman believe that the government's insistence on agreements and red-tape have reduced technology transfer successes. Factors such as increased paperwork and the government's insistence on accountability contribute to the problem (50: 34; 51: 348).

<u>**Long-term Metrics.**</u> WL currently uses qualitative, anecdotal success stories to track the effectiveness of their technology transfer process (79). However, many of the respondents provided opinions as to how they would also measure using quantitative, long-term metrics. These suggested long-term metrics were widely dispersed across several categories, illustrating the real world difficulties involved with measurement of technology transfer. Literature would suggest that WL consider measuring to control accomplishment of technology transfer objectives using both qualitative and quantitative metrics (5: 72; 69: 8). Qualitative metrics bring life to the technology transfer process due to their anecdotal elements. It has also been presented that the long-term quantitative metrics gauge the value of the technology to the commercial sector. Long-term metrics interest congress due to their general market impact nature.

The TTO has also provided guidance on long-term metrics. They have requested that the amount of revenue generated by the laboratory technology transfer activities be tracked as a long term indicator of effectiveness (78). This metric, although easy to count, is of limited value towards driving appropriate behavior and determining accomplishment of the Air Force Material Command (AFMC) technology transfer objective. To obtain royalty revenues an organization must have established an agreement. As previously discussed, agreements deter transfer (50: 34; 51: 348). A briefing presented at the October 1994 AFMC Technology Transfer Working Group Meeting suggested that the recent thrust to push technology transfer has most likely stunted it (78). Royalty revenues as a metric or indicator of technology transfer objective accomplishment is faulty because

government patents and licenses are a minuscule portion of the long-term technology transfer impact (51: 346).

How Does WL Control Their Technology Transfer Program?

WL is currently not adequately controlling their technology transfer program. They have elements of a control mechanism in portions of their laboratory, but they are not uniform and pervasive. Their technology transfer objectives are not consistently defined. The modified technology push process is evident, but not uniformly used, within WL. Finally, CRDAs and qualitative success stories do not provide adequate process information to enable accurate decision-making about resource utilization for technology transfer.

In conclusion, it is difficult to control technology transfer. Technology transfer control is essentially an unknown field. The problems discussed in Table 5.1 are a predominant factor in this difficulty. However, other barriers to controlling technology were also drawn from the interviews and are presented in Table 5.2. The numerous occurrence these of difficulties during the interviews further confirms the dilemma of technology transfer control.

TABLE 5.2

GENERAL CONCLUSIONS ON TECHNOLOGY TRANSFER CONTROL

1. The technology transfer process is difficult to understand.
2. Technology transfer success is hard to define.
3. Technology transfer is difficult to measure in both the near and long term.
4. No one metric will completely measure technology transfer effectiveness.

The conclusions of this research are not meant to be generalized to all federal laboratories. However, they can be useful to these organizations. Review of the literature and other case studies suggest the presence of these same issues within other federal laboratories.

Recommendations for Future Research

Future researchers interested in technology transfer can take advantage of a relatively new field of exploration. The following topics are recommended opportunities to continue the investigation of technology transfer.

Bench Marking. The focus of research would be to bench mark federal laboratories in the following technology transfer areas:

1. Setting organizational objectives for technology transfer.
2. Technology transfer processes that optimize the developer-adopter relationship.
3. Technology transfer metrics in both the near-term and long-term.

Predictive Capability. Many researchers believe that in order to manage and control a process, a predictive capability is imperative. Research might examine the laboratories for any presence of this capability. Additionally, a sampling methodology might be performed to continue to characterize the input elements of a successful technology transfer program.

Technology Transfer Control. Potential researchers might continue the research of control of technology transfer programs by performing a case study on other federal research and development laboratories. Consideration should be given to the limitations provided in Chapter Three of this research.

Summary

The objective of this research was to explore the subject of technology transfer control within WL. Research objectives included:

1. Determine the motives for WL participation in technology transfer.

2. Determine the technology transfer process in WL.

3. Determine the measures to assess the success of the technology transfer program.

Several technology transfer topics were reviewed in the literature. Case study interviews were collected among the WL Office of Research and Technology Applications (ORTA), technology transfer focal points in the directorates, and WL management. These interviews were used to baseline the current status of technology transfer control in WL. Although WL is working on a majority of the elements of technology transfer control, the difficulty in controlling technology transfer was fortified by the respondents' answers. This research may heighten the awareness of other federal laboratories and research and development centers of the barriers to controlling technology transfer.

Recommendations for future research were provided for interested technology transfer efforts. Potential research areas included bench marking the elements of technology transfer in federal laboratories, exploring the predictive capability of the technology transfer process, and continuing this technology transfer control research in other federal laboratories.

Appendix A: Acronyms

AITP:	Aerospace Industry Technology Program
AF:	United States Air Force
AFB:	Air Force Base
AFIT:	Air Force Institute of Technology
AFMC:	Air Force Material Command
AFMC/CC:	The Commander of Air Force Material Command
AFMC/ST:	Air Force Material Command, Science and Technology
AFPD:	Air Force Policy Directive
AFSC:	Air Force Systems Command
ARPA:	Advanced Research Project Agency
ATP:	Advanced Technology Program
BRAC:	Base Realignment and Closure Board
CIT:	Center for Innovative Technology
CRDA:	Cooperative Research and Development Agreement
DOC:	Department of Commerce
DOD:	Department of Defense
DOE:	Department of Energy
DOT:	Department of Transportation
FLC:	Federal Laboratory Consortium
GCATT:	Gulf Coast Alliance for Technology Transfer
GOCO:	Government Owned/Contractor Operated
IG:	Inspector General
IPT:	Integrated Product Team
JPO:	Joint Program Office
KSC:	Kennedy Space Center

NAC:	National Automotive Center
NASA:	National Aeronautics and Space Agency
NASP:	National Aero-Space Plane
NBS:	National Bureau of Standards
NIST:	National Institute for Standards and Technology
ORTA:	Office of Research and Technology Applications
PAT:	Process Action Team
SAE:	Society of Automotive Engineers
SBIR:	Small Business Innovative Research
SPO:	System Program Office
STTR:	Small Business Technology Transfer Act
RTTC:	Regional Technology Transfer Center
TAP:	Technology Access Program
TCCP:	Tri-Cities Commercialization Partnership
TRP:	Technology Reinvestment Program
TTO:	Technology Transition Office
U.S.:	United States
WL:	Wright Laboratory
WL/CC:	The Commander of Wright Laboratory
WL/DOR:	Wright Laboratory Operations Directorate
WTN:	Wright Technology Network

Appendix B: Interview Questions

GENERAL INFORMATION

1. How long have you been employed with the government?

2. How long have you been employed with WL?

3. How many years of technology transfer experience have you had with WL?
- Outside of WL?

4. What is your current job?

5. Do you use contractor provided services support for your technology transfer program? If so, briefly describe what they do for you ?

TECHNOLOGY TRANSFER PROCESS

1. Does the WL organization screen technology for potential commercial applications?
- If so, how?

2. How is technology marketed for potential technology transfers?

3. Would you classify your technology transfer strategy as (1) WL proactively seeking opportunities to make technologies available for commercial people, or (2) WL desiring commercial people to identify the technologies they want, and initiating the action, (3) a combination of both?

4. Would you say the WL organization is more interested in envisioning and pursuing potential commercial applications, or answering requests for help from potential commercial users of technology?

5. What is the annual budget for technology transfer in WL?
- FY93
- FY94
- FY95

6. How many government people are involved with technology transfer in WL?

7. How are potential technology transfers facilitated?

TECHNOLOGY TRANSFER PROCESS (cont)

8. How do you maintain contact with technology transfer adopters during the technology transfer?
- After the technology transfer?

9. Does the technology transfer process support the transfer of contractor developed <u>and</u> in-house technology?

10. Do you incentivize your technology developers (both in-house and contractors) to transfer technology?
- If so, how?

ORTA AND WL ORGANIZATIONS

1. Where does the ORTA fit within WL?

2. What is the annual budget of WL?

3. How many people work in WL?

4. What are the roles of all the technology transfer players in WL?

ORGANIZATIONAL OBJECTIVES

1. What is the mission of WL?

2. What are the objectives of WL with regard to technology transfer?

METRICS

1. How do you define successful technology transfer?

2. How do you measure the technology transfer process in the near or intermediate terms (metrics)?

3. How do you measure the benefit of technology transfer (metrics)?

4. What mechanisms do you use to collect technology transfer data?

5. Does WL track technology transfer metrics at the WL level or at a lower level such as within the ORTA?

6. What do you see as the barriers for WL in measuring technology transfer?

Additional Comments:

Appendix C: Interview Matrix

TABLE C.1

INTERVIEW MATRIX

	ORTA	WL Mgt	Focal Points	Data Collection
Process				
Question 1	X		X	interview
Question 2	X		X	interview
Question 3	X	X	X	interview
Question 4	X	X	X	interview
Question 5	X			interview,document
Question 6	X			interview,document
Question 7	X		X	interview
Question 8	X		X	interview
Question 9	X		X	interview,document
Question 10	X		X	interview,document
Organization				
Question 1	X			interview,document
Question 2	X			interview,document
Question 3	X			interview,document
Question 4	X		X	interview,document
Objectives				
Question 1	X	X	X	interview,document
Question 2	X	X	X	interview,document
Metrics				
Question 1	X	X	X	interview
Question 2	X		X	interview,document
Question 3	X	X	X	interview,document
Question 4	X		X	interview,document
Question 5	X	X	X	interview
Question 6	X		X	interview

Appendix D: Wright Laboratory Interview Results

TECHNOLOGY TRANSFER PROCESS

1. Does the WL organization screen technology for potential commercial applications?
- If so, how?

ORTA Level

- No, but we are working towards this
- Yes, to some extent, but not as much as we should
- No algorithm for weighing commercial applications

Directorate Focal Point Level

- Yes, we analyze technology for technology tranfer potential and develop a transfer plan.
- We ask people to do this.
- Not that I know of.
- Making it part of the acquisition process and planning in users needs during pre-award.

2. How is technology marketed for potential technology transfers?

ORTA Level

- Wright Technology Network (WTN) markets the technologies for WL, but they are not doing as effectively as they should.
- Advertising, word-of-mouth, conferences, and a success stories book from WL/DOR.
- WL/DOR is responsible for marketing in a technology push environment.

Directorate Focal Point Level

- Advertisements, articles, Internet, Commerce Business Daily, and word-of-mouth.
- Not marketed that much. WL/DOR is responsible for marketing.
- Word-of-mouth, displays, symposiums, speaking arrangements, and WTN.
- Brochures, newsletters, advertisements, focused target discussions, multiplier groups, manufacturing extensions centers and other societies. Marketing imbedded in the program. Build user needs into the technology development program.

3. Would you classify your technology transfer strategy as (1) WL proactively seeking opportunities to make technologies available for commercial people, or (2) WL desiring commercial people to identify the technologies they want, and initiating the action, (3) a combination of both?

ORTA Level

- Combination of both. Directorates are now looking for technology matches.
- Combination of both. Rely on requests for help, as well as proactively telling the world so they know to come.
- Mixed bag. Combination of inquiries from outside and questions about what WL has.

Directorate Focal Point Level

- A combination of both. Must proactively plan the technology to include industry needs.
- Definitely technology push (1).

WL Management Level

- We just sit around and wait for the phone calls (2).

4. Would you say the WL organization is more interested in envisioning and pursuing potential commercial applications, or answering requests for help from potential commercial users of technology?

ORTA Level

- Depends upon where you are in the laboratory. Some technologies have to be pushed; some have to be pulled.
- Envisioning and pursuing, but you can not ignore the other.
- Answering requests for help.

Directorate Focal Point Level

- WL, in general, is more interested in answering requests for help. Our directorate is most interested in envisioning and pursuing.
- Envisioning and pursuing.
- Answering requests for help.

WL Management Level

- Answering requests for help.

7. How are potential technology transfers facilitated?

ORTA Level

- Informal communication and informal agreements (people to people). Patents are not productive. Cooperative Research and Development Agreements (CRDAs) are only a minor player.
- A mixture of informal (communication) and formal (CRDAs, patents and liscences) tools.

Directorate Focal Point Level

- CRDAs and liscences.
- Software release agreements. Communication between the developer and adopter.
- Mostly formal mechanisms, but CRDAs are just a small part.
- Existing relationships and networks.
- Using the actual contractual vehicles that developed the technology. Making changes to the technology during development to encourage transfer.

8. How do you maintain contact with technology transfer adopters during the technology transfer?
- After the technology transfer?

ORTA Level

- Informal communication between the directorate engineer and the outside partner. Documentation when it can be produced. Afterwards, we have never had the luxury to follow-up.
- The technology developer stays in touch with the outside partner until the problem is solved. CRDAs require a half page write-up at the conclusion of the effort. No follow-up on CRDA when it is closed out.
- None.

Directorate Focal Point Level

- CRDA addresses communication. After the CRDA a network is built around the technology with a common area of interest between the developer and adopter.
- None, other than a continuing relationship.
- Informal things such as phone calls and meetings. CRDA requires a formal report. A network is built so when the developer and adopter see each other an update is relayed.
- The developer and implementor are tied together and communication is built into the contractual agreement and source selection criteria. A network is established.

9. Does the technology transfer process support the transfer of contractor developed and in-house technology?

ORTA Level

- Yes, but we push in-house technologies first due to scarce resources. They own the intellectual property rights to their technology.
- Stick primarily to in-house technologies due to property rights.

Directorate Focal Point Level

- Yes, but we are most familiar with in-house technology.
- Should be left up to contractor who develops technology because we do not have the rights to the technology.

10. Do you incentivize your technology developers (both in-house and contractors) to transfer technology?
- If so, how?

ORTA Level

- Some directorates include clauses in their contracts addressing transfer of technology. Recognition awards are also used.
- 20% of all royalties from patents go to the developer.
- It is in every job description.

Directorate Focal Point Level

- Technology transfer awards, royalty income, and evaluated for promotion purposes.
- No incentive in contracts for technology transfer.
- Award criteria for source selection. Do not want to bribe people to transfer technology.

ORTA AND WL ORGANIZATIONS

1. Where does the ORTA fit within WL?

ORTA Level

- Within the technology transition division of the Plans and Programs Directorate (WL/XPT).

4. What are the roles of all the technology transfer players in WL?

ORTA Level

- Focal points sit between Staff ORTA and technologist. ORTA facilitates betwen WL, state, local and federal customers. Specialists build interaction between particular technology fields and technology adopters.
- ORTA is responsible for policy, directing all technology transfer activities, and keeping the CRDAs. Focal points are familiar with their directorates' technology. Specialists have developed contacts in particular areas and match technology needs with WL capabilities. Special Assistant for Technology Transfer is an ambassador to outside agencies. Scientists and engineers talk with industries, solve their problems and execute the CRDAs.
- Some are gatekeepers. Some are champions. ORTA responsible for marriage brokering and facilitating.

Directorate Focal Point Level

- WL/CC is the champion. ORTA is the facilitiator. Focal points are CRDA experts. Scientists and engineers work with adopters, create the CRDAs and answer technical requests.
- Focal points manage the awards programs, work with the lawyers, and relay guidance to the developers. WTN brings companies to visit the engineers.
- Contractors are the developers and adopters. Focal points are the sponsors. ORTA is responsible for pushing existing technology.

ORGANIZATIONAL OBJECTIVES

1. What is the mission of WL?

ORTA Level

- Create what is needed for aircraft.
- Provide technology to military systems.
- Develp technologies needed to keep the United States at the forefront of technology.

Directorate Focal Point Level

- Developing technology and transitioning it to aircraft.
- Research and development of advanced technologies to keep United States fighting forces superior in to the 21st century.

WL Management Level

- Provide research and development to the United States. Spin-on/Spin-off technology from defense research and development.

2. What are the objectives of WL with regard to technology transfer?

ORTA Level

- Enhance the connectivity of WL technology to the traditional and nontraditional customers.
- Create as many CRDAs as possible to help industries in Southwest Ohio and nationwide. Create jobs. Help small businesses.
- Required by regulation.

Directorate Focal Point Level

- Drivedown the price of technology.
- Royalties.
- Revitalization of American industrial base.
- Keep American preeminence in technology and ensuring technology is available.
- Keep WL alive.

WL Management Level

- Drive down the cost of products.
- Retain local technical jobs.

METRICS

1. How do you define successful technology transfer?

ORTA Level
- Something that works.
- Something that solves a problem.
- Creation of jobs in the American sector.

Directorate Focal Point Level
- Anything we do to get military technology into commercial hands.
- Creating products.
- Disseminating information.
- Success to both WL and outside partner.
- Saving companies money through reduced research and development costs.

WL Management Level
- Products and processes into the commercial world based on military technology.

2. How do you measure the technology transfer process in the near or intermediate terms (metrics)?

ORTA Level
- Does not know of any official way. Tracks return business at a personal level.
- Number of CRDAs.
- Number of phone calls to WL for technical information.
- No current way.

Directorate Focal Point Level
- We don't really measure. CRDA count was the easy thing to do.
- Keep track of the things we are doing.
- Agreements we are involved in.
- Don't really have one.
- Projects and how many different things we are working on.
- Phone calls, documents, outreach activities. CRDAs are very minor and not close to the whole transfer picture.
- CRDAs.
- Increases in industry calling or commercial reasons.
- Cost, schedule and performance of CRDAs.

3. How do you measure the benefit of technology transfer (metrics)?

ORTA Level

- Economic impact.
- WL receiving the intent of the CRDA.
- Data to further WL research.
- Advancement of technology because we are working with commercial users.
- Revenues for the laboratory, although not the primary reason.

Directorate Focal Point Level

- Not anything.

WL Management Level

- WL growing during the defense down-sizing.
- Revenues to the laboratory.
- Patents.
- Increase in CRDAs.

4. What mechanisms do you use to collect technology transfer data?

ORTA Level

- No time to bother with data collection.
- None.

Directorate Focal Point Level

- Informal communication links with industry.
- Does not know of any.
- Written and telephone surveys.

5. Does WL track technology transfer metrics at the WL level or at a lower level such as within the ORTA?

ORTA Level

- ORTA level.
- WL/CC maintains visibility of CRDAs.

Directorate Focal Point Level

- Metrics do not go to WL/CC.
- Just CRDAs go to WL/CC. We collect other things that do not go to WL/CC.

WL Management Level

- WL/CC.

6. What do you see as the barriers for WL in measuring technology transfer?

ORTA Level

- No time to follow up.
- Time for benefits to evolve.
- No feedback from indusry.
- Turnover of people on the outside.
- Small companies do not have time to provide feedback.
- Feedback is usually faulty.
- Beauty is in the eye of the beholder.
- Economic data is subject to customer perception.
- People do not understand the transfer process.
- Level of understanding that management has.

Directorate Focal Point Level

- Data collection problems.
- People not providing feedback.
- No one understands success.
- Understanding the process.
- Clear technology transfer goals need to be defined.
- Unknown, new process.
- No one measure that does everyting.
- Measuring is time-consuming.

ADDITIONAL COMMENTS

ORTA Level

- Technology transfer is a cultural change.
- Integrate it into everyday investment strategy

Directorate Focal Point Level

- Not enough people and not enough time.

WL Management Level

- Last two years have seen tremendous change. What will the next two years bring?

Bibliography

1. Lee, Joseph W. "Improvement of Technology Transfer from Government Laboratories to Industry," Technology Transfer in a Global Economy, Proceedings of the Technology Transfer Society 15th Annual Meeting, International Symposium and Exhibit: 345-353 (June 1990).

2. Guilfoos, Stephen J. Senior Engineer and Technical Advisor for the Air Force Material Command Technology Transfer Team, Wright-Patterson AFB OH. Personal interview. 12 January 1994.

3. Chapman, Richard L. "Case Studies in the Tracking and Measuring of Technology Transfer," Technology Transfer Society Technology Transfer Proceedings, 19th: 164-171 (June 1994).

4. Bozeman, Barry. "Evaluating Technology Transfer Success: A National Survey of Government Laboratories," Technology Transfer Society Technology Transfer Proceedings, 16th: 138-153 (June 1991).

5. Spann, Mary S. and others. "Improving Federal Technology Commercialization: Some Recommendations from a Field Study," Journal of Technology Transfer, volume 18, numbers 3 & 4: 63-74 (Summer 1993).

6. Emory, C. William and Donald R. Cooper. Business Research Methods (Fourth Edition). Boston MA: Richard C. Irwin, Inc, 1991.

7. ASC/NA. "An Investigation of the Concepts of Dual-Use Technology, Defense Conversion, and Industrial Policy with Potential Implications for the NASP Program." Unpublished report. Contract F33657-87-C-0210 with Science Applications International Corporation (SAIC). Wright-Patterson AFB OH, May 1993.

8. Minutes of the 19 July 1994 AFMC Technology Transfer Working Group Meeting, San Antonio TX, August 1994.

9. Hamner, Kenneth L. and Charles A. La Fleur. An Exploratory Survey of Methods Used to Develop Measures of Performance. MS thesis, AFIT/GSM/LAS/93S-6, Air Force Institute of Technology (AETC), Wright-Patterson AFB OH, September 1993 (AD-A 273945).

10. ASC/SMT. "AFMC Technology Transfer Process Action Team." Wright-Patterson AFB OH, July 1992.

11. Chapman, Richard L. "Measuring Technology Transfer Success: Overcoming the 'If You Can't Count It, It Doesn't Count' Syndrome," Technology Transfer Society Technology Transfer Proceedings, 18th: 13-19 (June 1993).

12. "Despite Lean Times, Budget Proposes Increases for R&D, Tech Transfer," McGraw-Hill's Federal Technology Report: 1-2 (9 February 1994).

13. ASC/NA. "Industrial Policy and the NASP Program." Unpublished report. Aeronautical Systems Center Reserve Officer Report Number 93-518-DAY, Wright-Patterson AFB OH, January 1994.

14. Reich, Robert B. The Work of Nations: Preparing the U.S. for 21st Century Capitalism. New York: A.A. Knopf, 1991.

15. Porter, Michael E. "The Competitive Advantage of Nations," Harvard Business Review: 73-93 (March-April 1990).

16. Carr, Robert K. "Doing Technology Transfer in Federal Laboratories," Journal of Technology Transfer, volume 17, number 2 & 3: 8-23 (Spring-Summer 1992).

17. Kasten, Terry D. Chief of Systems Applications, NASP JPO, Aeronautical Systems Center, Wright-Patterson AFB OH. "NASP Contribution to the National Industrial Base." Briefing to Assistant Secretary of the Air Force for Acquisition. Washington DC, January 1993.

18. Heberling, Michael E. "Defense Industrial Base Policy: Revisited," Acquisition Review Quarterly, volume 1, number 3: 238-249 (Summer 1994).

19. Rusinko, Cathy A. Assistant Professor, Department of Management, Villanova University, Villanova PA. Personal interview. Huntsville AL, 24 June 1994.

20. Department of the Air Force. Value of NASP to this Country: The Return on Investment from a National Perspective. Washington DC: Office of the Assistant Secretary of Defense, 12 Nov 1992.

21. Adams, Mel and others. "Attitudes Toward Federal Technology Commercialization," Technology Transfer Society Technology Transfer Proceedings, 19th: 94-99 (June 1994).

22. Roman, Daniel E. Science, Technology, and Innovation: A Systems Approach. Columbus OH: Grid Publishing, Inc., 1980.

23. AFMC/ST. "Command Technology Transfer Metrics." Unpublished briefing. Air Force Material Command Horizons Conference, Wright-Patterson AFB OH, June 1994.

24. Dawson, P. A. An Exploratory Study of Domestic Technology Transfer Concepts, Federal Infrastructure and Process Models. MS thesis, AFIT/GLM/LSM/86S-14. School of Systems and Logistics, Air Force Institute of Technology (AU), Wright-Patterson AFB OH, 1986 (AD-A 174541).

25. Dakin, Karl J. and J. Lindsay. Technology Transfer: Financing and Commercializing the High Tech Product or Service. Chicago: Probus Publishing Company, 1991.

26. Department of the Air Force. Scientific/Research and Development: Domestic Technology Transfer. AFPD 61-3. Washington DC: SAF/AQT, 15 November 1993.

27. "Small Rise in R & D Spending Seen; Federal Distribution Altered," McGraw-Hill's Federal Technology Report: 2-3 (7 January 1993).

28. "ARPA Advances $500M Offering Under Defense Conversion," McGraw-Hill's Federal Technology Report: 1, 8 (18 March 1993).

29. Adams, Mel and others. "Potential Partners' Interest in Dual-Use Technologies," Technology Transfer Society Technology Transfer Proceedings, 19th: 440 (June 1994).

30. "Clinton Plans to Double Funds for Commerce's Tech Programs," McGraw-Hill's Federal Technology Report: 3 (20 January 94).

31. Loveless, Bill. "NIST Draft Plan Would Establish up to 180 Manufacturing Centers," McGraw-Hill's Federal Technology Report: 1-2 (7 January 1993).

32. Loveless, Bill. "NIST May Use New ATP Format More Than It Expected in '94," McGraw-Hill's Federal Technology Report: 1,8 (20 January 1994).

33. "Increases Sought for DOT R&D, Including 'Intelligent' Roads," McGraw-Hill's Federal Technology Report: 6 (17 February 1994).

34. "All's Not Bad at NASA: Budget Contains $608 Million for Tech," McGraw-Hill's Federal Technology Report: 5-6 (17 February 1994).

35. "Pentagon Seeks $625 Million for Tech Reinvestment Project," McGraw-Hill's Federal Technology Report: page 4 (17 February 1994).

36. United States Congress. House of Representatives Conference Report 103-339. House Resolution 3116, 103rd Congress. Washington DC: GPO, 9 Nov 1993.

37. Leach, D. "Economic Metrics for the Technology Reinvestment Program." Unpublished report to the 1994 Society of Automotive Engineers (SAE). Dayton OH, 20 April 1994.

38. Digman, L. A. "A Synthesis of Pertinent Research Relating to Technical Information Systems," Journal of Technology Transfer Volume 3, number 2: 37-42 (1979).

39. Dorf, Richard C. and Kirby K. F. Worthington. "Models for Commercialization of Technology from Universities and Research Laboratories," Journal of Technology Transfer, volume 12, number 1: 1-8 (1987).

40. Souder, William E. and others. "A Guide to the Best Technology Transfer Practices," Journal of Technology Transfer, volume 15, numbers 1 & 2: 5-16 (Winter-Spring 1990).

41. The Random House College Dictionary (Revised Edition): New York: Random House, Inc., 1982.

42. Gansler, Jacques S. Affording Defense. Cambridge MA: The First MIT Press, 1991.

43. Schweikart, Larry. "Quarterly Report #5: Program Management Document, Managing the NASP: Managing the Technology of the X-30 Project, 1982-1991." Contract F33657-87-C-0210 with Science Applications International Corporation (SAIC). Unpublished Report. ASC/NA. Wright-Patterson AFB OH, 1994.

44. West, William K. and Jennifer L. Mitchell. "National Aero-Space Plane Contributions to the Automobile Industry," Technology Transfer Society Technology Transfer Proceedings, 19th: 119-124 (June 1994).

45. Department of the Air Force. Technology Transfer Guidebook. Air Force Development Test Center, Eglin AFB FL, June 1994.

46. AFMC/CC. "New Command Metrics." Unpublished briefing. Air Force Material Command Horizons Conference, Wright-Patterson AFB OH, June 1994.

47. Lewis, Roger A. "U.S. Department of Energy Technology Transfer: Strategic Vision and Mission," Technology Transfer Society Technology Transfer Proceedings, 19th: 109-117 (June 1994).

48. Lessard, Pamela. "NASA Adopts Agenda to Promote Tech Transfer as Major Duty," McGraw-Hill's Federal Technology Report: pg 1-2 (21 July 1994).

49. West, William K. Chief of Technology Applications, NASP JPO, Aeronautical Systems Center, Wright-Patterson AFB OH. "NASP Advanced Technology Demonstration Engine." Briefing to the Undersecretary of Commerce for Technology. Washington DC, 12 July 1994.

50. Bozeman, Barry and Michael Maurice Crow. "Red Tape and Technology Transfer in U.S. Government Laboratories," Journal of Technology Transfer: 29-37 (Spring 1991).

51. Deonigi, D. E. and others. "The Technology Transfer Process: Background for the National Energy Strategy," Technology Transfer in a Global Economy, Proceedings of the Technology Transfer Society 15th Annual Meeting, International Symposium and Exhibit: 327-334 (June 1990).

52. Roessner, J. David and Alden S. Bean. "Industry Interactions with Federal Laboratories," Journal of Technology Transfer, volume 15, number 4: 5-14 (Fall 1990).

53. Weijo, Richard O. "Strategies for Promoting Technology Transfer to the Private Sector," Journal of Technology Transfer, volume 11, number 2: 43-61 (1987).

54. Bagur, Jacques D. and Ann S. Guissinger. "Technology Transfer Legislation Overview," Journal of Technology Transfer, volume 12, number 1: 51-63 (1987).

55. Devine, Michael D. and others. "Government Supported Industry-University Research Centers: Issues for Successful Technology Transfer," Journal of Technology Transfer, volume 12, number 1: 27-36 (1987).

56. Guilfoos, Stephen J. "Measuring Transfer Effectiveness or Why Don Quixote Tilts at Windmills," Technology Transfer Society Technology Transfer Proceedings, 19th: 172-176 (June 1994).

57. Strunk, Dave. "GCATT: Learning by Doing," Technology Transfer Society Technology Transfer Proceedings, 19th: 293-299 (June 1994).

58. Kinney, Frank. "Florida/NASA-KSC Technology Transfer Partnership," Technology Transfer Society Technology Transfer Proceedings, 19th: 300-303 (June 1994).

59. Culp, Rhonda P. "State Level Programs for Technology Transfer," Technology Transfer Society Technology Transfer Proceedings, 19th: 338-344 (June 1994).

60. Griffith, Melanie C. "The Tri-Cities Commercialization Partnership for Environmental Technologies: Economic Development That Works," Technology Transfer Society Technology Transfer Proceedings, 19th: 356-363 (June 1994).

61. Harrell, Robert W. Jr. "Transferring Technology Through University, Industry, and Public Agencies Partnerships," Technology Transfer Society Technology Transfer Proceedings, 19th: 364-371 (June 1994).

62. Chard, William. "Integrated Model for Technology Commercialization and Resource Utilization," Technology Transfer Society Technology Transfer Proceedings, 19th: 395-401 (June 1994).

63. Sayles, David C. "Anticipated Barriers Confronting the Implementation of Technology Transfer," Technology Transfer Society Technology Transfer Proceedings, 19th: 463-469 (June 1994).

64. United States Congress. The Stevenson-Wydler Technology Innovation Act of 1980, Public Law 96-480. 96th Congress. Washington DC: GPO, 1980.

65. Kramer, David. "Gauging Tech Transfer is Tough, DOE's Oak Ridge Operator Finds," McGraw-Hill's Federal Technology Report: pg 11-12 (23 June 1994).

66. Geisler, Eliezer. "Commercializing Technology from Federal Laboratories: A Model and a Study of Mechanisms and Outputs," Technology Transfer Society Technology Transfer Proceedings, 19th: 61-67 (June 1994).

67. Baily, Thomas E. and others. "A Company Profile for Technology Transfer Success," Technology Transfer Society Technology Transfer Proceedings, 19th: 151-163 (June 1994).

68. "U.S. R&D Expenditures to Rise Slightly in '94, Battelle Says," McGraw-Hill's Federal Technology Report: 6 (6 January 1994).

69. Spann, Mary S. and others. "Measures of Technology Transfer Effectiveness: Key Dimensions and Differences in Their Use by Sponsors, Developers and Adopters." Unpublished article. College of Administrative Science, University of Alabama in Huntsville, Huntsville AL, 1994.

70. Chapman, Richard L. "The Technology Transfer Act of 1986: Promise, Shortfall, and Future," Technology Transfer Society Technology Transfer Proceedings, 15th: 335-343 (June 1990).

71. Loveless, Bill. "NASA Starts Probing Partners on Market Impact of Projects," McGraw-Hill's Federal Technology Report: pg 1-2 (23 June 1994).

72. Geisler, Eliezer. "Key Output Indicators in Performance Evaluation of Research and Development Organizations." Unpublished article. Department of Management, University of Wisconsin-Whitewater, Whitewater WI, March 1994.

73. Marshall, Catherine and Gretchen B. Rossman. Designing Qualitative Research. Newbury Park CA: Sage Publications, 1989.

74. Yin, Robert K. Case Study Research: Design and Methods. Newbury Park CA: Sage Publications, 1989.

75. Patton, Michael Quinn. Qualitative Evaluation Methods. Beverly Hills CA: Sage Publications, 1980.

76. Gummesson, Evert. Qualitative Methods in Management Research. Lund Sweden: Krieger Publishing Company, 1988.

77. Khuri F. Paul and Howard M. Plevylak. An Investigation of Integrated Product Development Implementation Issues: A Case Study of Bosma Machine and Tool Corporation. MS thesis, AFIT/GSM/LAS/93S-11. School of Systems and Logistics, Air Force Institute of Technology (AETC), Wright-Patterson AFB OH, September 1993 (AD-A 273917).

78. Personal notes of the 24-26 October 1994 AFMC Technology Transfer Working Group Meeting. Griffiss AFB NY, October 1994.

79. WL/DOR. "Air Force Science and Technology: Wright Laboratory Success Stories." Unpublished brochure. Wright Laboratory, Aeronautical Systems Center, Wright-Patterson AFB OH, 1993.

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13. ABSTRACT *(Maximum 200 words)*

Federal laboratories, system product centers, and military logistics centers are being challenged to leverage national investments in technology beyond their traditional customer base--technology transfer. Participation in domestic technology transfer is growing at an astounding rate. Additionally, the federal government has invested and continues to invest billions of dollars into active defense conversion, dual-use technology, and technology transfer.

The objective of this research is to explore how one government laboratory controls its technology transfer process, in both the near and long terms. This research examines the motives for participating in technology transfer. The researcher presents several of the processes that are used throughout the federal laboratory system and recommends the process model best suited for active technology transfer organizations. The research also discusses near and long term metrics and their suitability for use. Additional topics investigated include technology transfer definitions, technology transfer laws, and barriers to measuring technology transfer.

The researcher interviewed participants at Wright Laboratory in a case study methodology to determine their method for control of their technology transfer process. Data are presented from these interviews and results examined. The researcher offers future opportunities for research in the area of technology transfer.

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